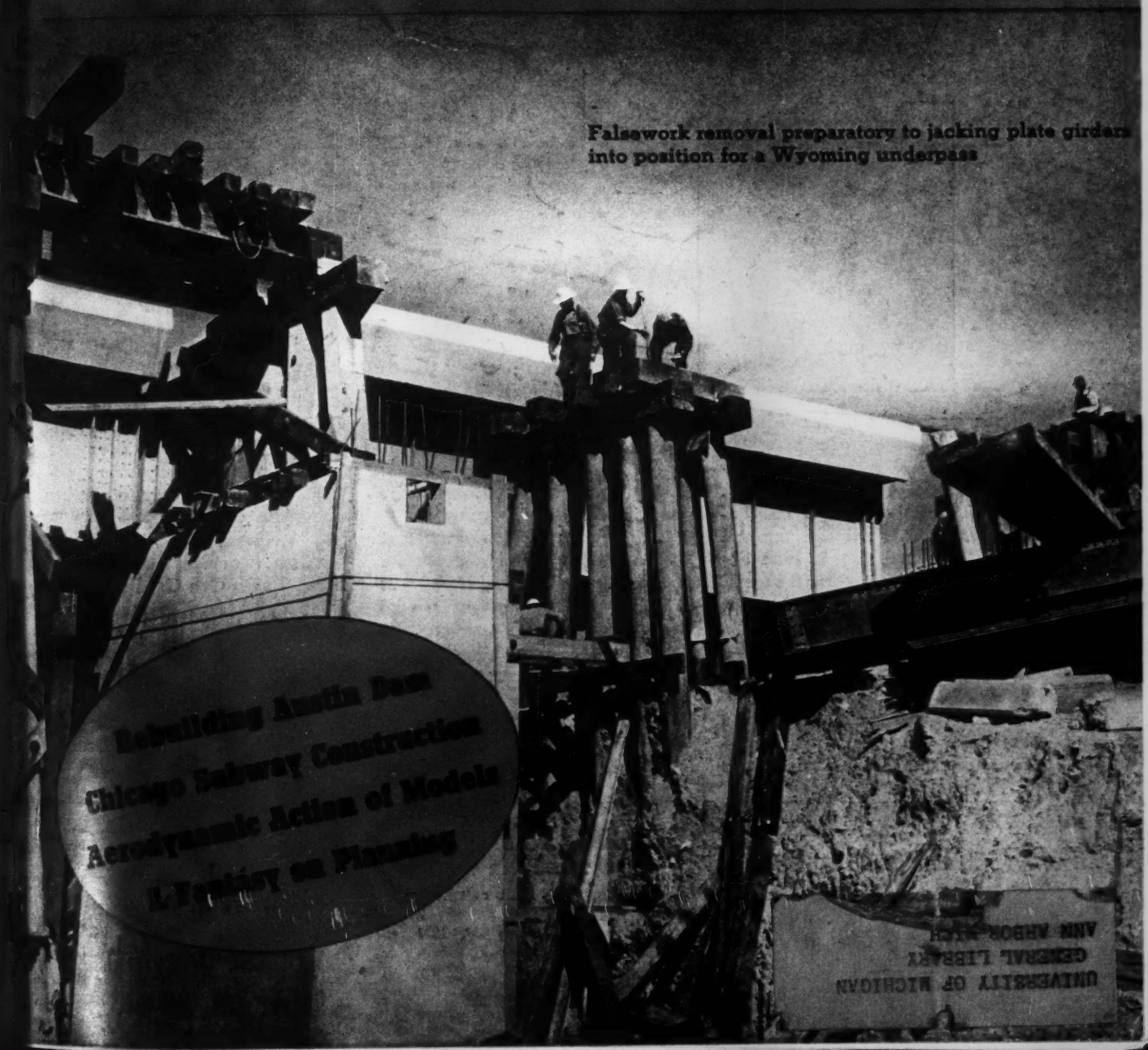
ENGINEERING NEWS-RECORD

JANUARY 30, 1941

FEB 1 1941



Falsework removal preparatory to jacking plate girders into position for a Wyoming underpass

Rebuilding Austin Dam

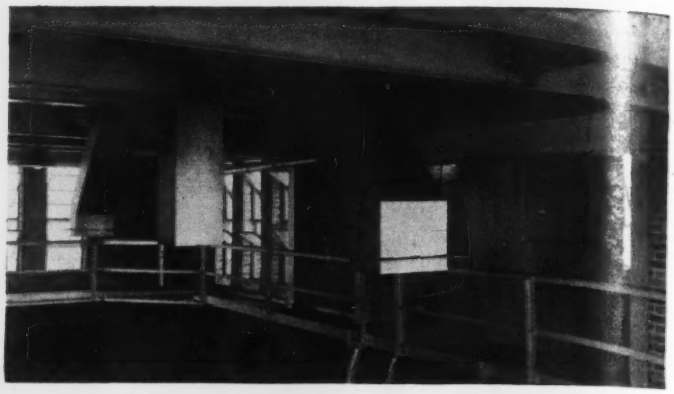
Chicago Subway Construction

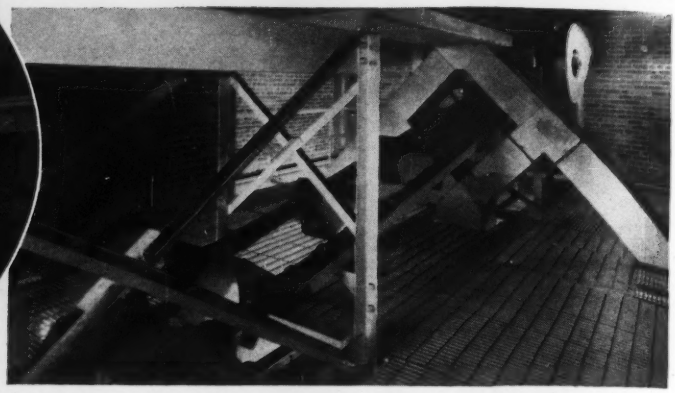
Aerodynamic Action of Models

Forestry on Planning

UNIVERSITY OF MICHIGAN
GENERAL LIBRARY
ANN ARBOR, MICH.

BYERS WROUGHT IRON





Defends this Boiler Plant Equipment Against Flue Gas and Fuel Corrosion

Steam generation with solid fuel brings a whole chain of corrosion problems that begin with the handling of the fuel and end only with the discharge of the products of combustion. Any sulfur in the fuel unites with moisture to form destructive acids that attack the metal storage and conveying equipment. This attack also occurs in the breeching and stack, supplemented by active carbonic acids from the union of CO_2 and moisture.

To combat this condition in the boiler house of the U. S. Department of Agriculture Laboratories at Beltsville, Maryland, wrought iron was used in a number of services as illustrated above; hopper, conveyor shaft, discharge chutes, and boiler breeching.

The superior service of wrought iron in applications like these is a matter of general record, and it is widely used by engineers who want to assure long, maintenance-free service. One railroad alone has used wrought iron in 18 coaling stations, while power plants throughout the country have installed it for bunkers, larries, spouts, gates, elevators, ducts, and stacks.

Our Engineering Service Department will be glad to give you information on any specific application. You will find an interesting discussion of the corrosion problems involved, and their successful solutions, in our bulletin, "Wrought Iron for Flue Gas Conductors and Coal Handling Equipment." A complimentary copy will be sent you on request.

A. M. Byers Co., Pittsburgh, Pa. Established 1864. Boston, New York, Philadelphia, Washington, Chicago, St. Louis, Houston, Seattle, San Francisco.

Genuine costs you more than Wrought Iron

BYERS GENUINE WROUGHT IRON

TUBULAR AND FLAT ROLLED PRODUCTS

STEEL TUBULAR PRODUCTS

ENGINEERING NEWS-RECORD

Devoted to Buildings, Sewers, Waterworks, Bridges, Highways, Streets, Dams, Foundations, Earthwork, Flood Control, Public Works, Irrigation, Canals, Railroads

Publication Office: 99-129 North Broadway, Albany, N. Y. • Editorial and Executive Offices: 330 West 42nd Street, New York

WALDO G. BOWMAN, *Editor* • ALBERT E. PAXTON, *Manager*

Vol. 126 JANUARY 30, 1941 No. 5

THIS WEEK

• Four shields under compressed air drove a total of 20,062 ft. of single-track tunnels for Chicago's initial subway system at an average advance of 25 ft. daily. It was necessary to remove the concrete-lined Chicago freight tunnel ahead of the shield and backfill with sand. Primary lining was fabricated structural steel segments. Mining out of area between tubes by hand for center platform stations was an interesting feature, along with others described in this issue.

• An ingenious method of installing a concrete box sewer underwater has been developed by Danish engineers. Hinged joints were used to permit quick assembly of precast units weighing 44 tons and 50 ft. long. Of special interest was the use of wood fiber packing which was compressed to solid wood when the joint was made up. A description of this project in Denmark appears on page 58.

• Our many readers engaged in rush defense construction — where economy must be maintained despite the necessity for speed and out of season construction—will find our illustrated review of new equipment and machines developed during the past year of unusual value—see section starting on page 68.

ENR ANNUAL REVIEW

• Following a custom that has found wide acceptance with our readers for many years past, the editors will devote the greater part of the issue of February 16 to a review of developments in civil engineering and construction during the year 1940. Each of the major divisions of the field will be separately treated and there will be a section of pictures and text reporting progress on the major projects that were under construction at the end of the year. Also included will be the statistics that mark the progress of the construction industry during the year.

PAGE

The Week's Events 19

Reader Comment 26

Editorials 28

Shield Tunneling on Chicago Subways 30

The Pharaoh and his Planning Board R. DENT PLANEUR 36

Aerodynamic Action on Wires and Bridges BLAKE D. MILLS, JR. 39

Symbols for Soils in Profile A. W. JOHNSON 41

Distribution System Records 42

Railroad Girder Spans Jacked into Place J. ROLAND CARR 44

Treated Water Facilities Supplant Tank Wagon Supply 46

Safety Through Traffic Engineering WILBUR S. SMITH 47

The Three Jewells—Pioneers in Mechanical Filtration
M. N. BAKER 51

Underpinning Austin Dam
GEORGE L. FREEMAN AND ROBERT B. ALSOP 52

Safe Plumbing—A Laboratory Tells All 57

Novel Joint Simplifies Sewer Construction R. HAFDAN-NIELSEN 58

Court Upholds Contractor's Claim FRANK WEINSTEIN 60

Book Notes and Reviews 61

Current Notes on Sewage Disposal 64

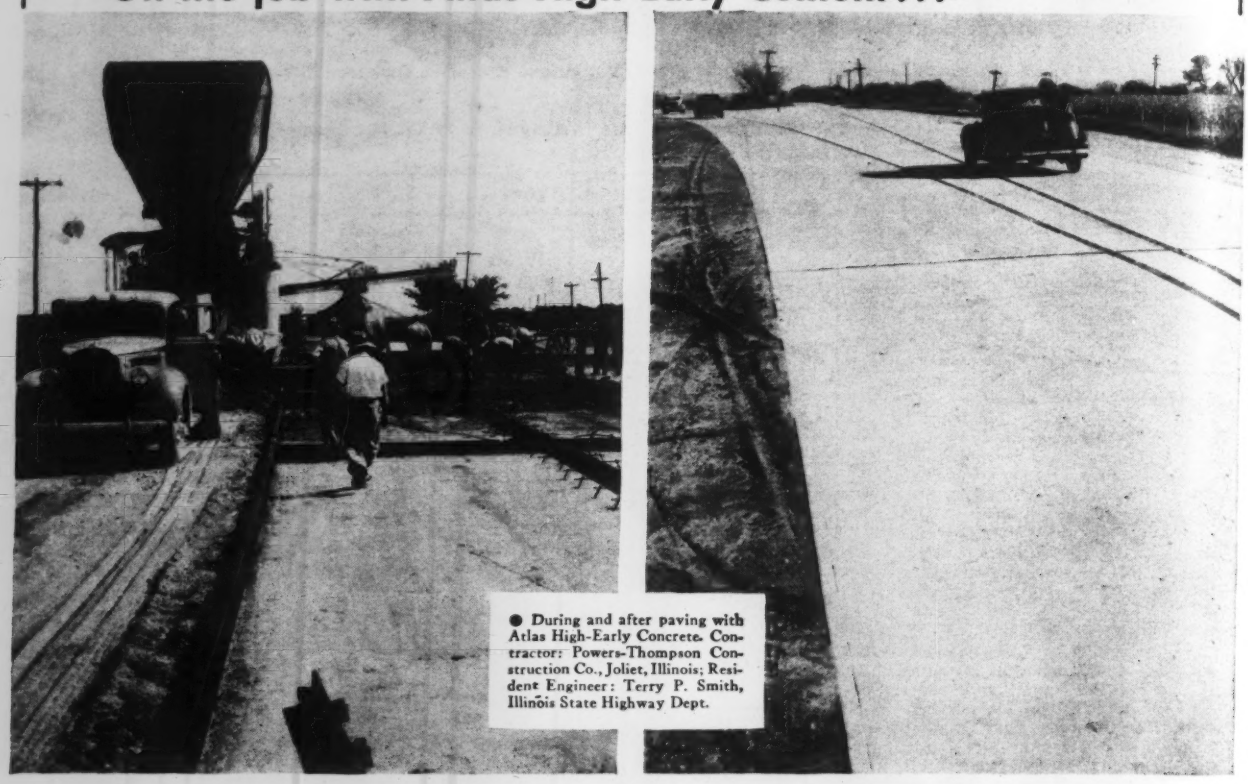
Unit Prices 66

Construction Equipment Review 68
A special section illustrating and describing nearly 200 machines of new and improved design

Number of copies of this issue printed: 35,003

CASE #31

On the job with Atlas High-Early Cement . . .



● During and after paving with Atlas High-Early Concrete. Contractor: Powers-Thompson Construction Co., Joliet, Illinois; Resident Engineer: Terry P. Smith, Illinois State Highway Dept.

REWARDED FOR SPEEDING ON A BUSY ROAD!

THE Illinois State Highway Department planned to connect two important state traffic routes with a new stretch of highway and a bridge.

PROBLEM: How to finish the existing gap in the shortest possible time; how to restore normal traffic flow on the highway quickly; and how to reduce maintenance of a 1,100-ft. detour.

THE ANSWER was simple. The Highway Department specified use of high-early-strength-cement — and the contractor selected Atlas High-Early cement.

RESULT: The gap was opened to traffic with a minimum of delay. Days were saved in completing the job. There also was a reduction in costs for protection and curing. Costs for maintaining the 1,100-ft. detour also were reduced because pavement was opened to traffic much sooner.

Engineers and contractors know they can depend upon Atlas High-Early cement to save them time and money. This cement gains working strength rapidly; cuts time for protection and curing as much as 60-70%; produces serviceable concrete in much less than the usual time; and often reduces form costs by permitting earlier stripping and reuse of forms.

Send today for interesting folder, "Case Histories of Days and Dollars," which tells how Atlas High-Early saved time and money on many jobs. Universal Atlas Cement Co. (United States Steel Corporation Subsidiary), Chrysler Building, New York City.

Offices: *New York, Chicago, Philadelphia, Boston, Albany, Pittsburgh, Cleveland, Minneapolis, Duluth, St. Louis, Kansas City, Des Moines, Birmingham, Waco.*

NR-H-26

ATLAS HIGH-EARLY CEMENT

A UNIVERSAL ATLAS PRODUCT

The Week In Engineering and Construction

"Better roads to aid defense" keynotes A.R.B.A. convention

Opening session speakers discuss economic phases of the national program and the need for proper relation between "the emergency" and long-range planning.

"Better roads to aid defense" was the keynote of President Hal G. Sours' address opening the 38th annual convention of the American Road Builders Association, held in New York Jan. 27-31. Large attendance and well-filled meetings indicated the importance of this meeting for highway engineers and contractors, although it was the off-year for the Road Show. The four-day program included general sessions covering basic highway problems and the usual group meetings devoted to technical subjects.

In the official welcoming address Mayor La Guardia reviewed the New York City highway system and the projects now under construction. He reminded engineers that expenditures for bridge and tunnel projects required extensive additional sums for approach facilities if public benefits were to be realized.

In the president's address Mr. Sours indicated that highways for defense could be divided into: (1) access routes to training areas, (2) roads into industrial plants, and (3) trunk highways. He pointed out the financing problems in connection with these various types of highways, indicating that many could be built by normal financing, while others of more direct military significance should receive a larger proportion of federal aid. He indicated that the problem of traffic congestion on routes approaching metropolitan areas and related financing of rights-of-way represented the most serious current problem, aside from the present emergency. Another point he stressed was need for highway builders and the industry to eliminate the phrase "highway costs," and talk more in terms of "highway investment" as an important point in developing public relations. In connection with the Pennsylvania Turnpike, Mr. Sours indicated that it was a valuable proving-ground to develop information on financing of highways by means of a service fee.

The remarks of Charles M. Upham, engineer-director of the A.R.B.A., emphasized the importance of the newest division of the organization which has been established to study economic phases of roadbuilding. A broad approach to this subject was contained in the paper written by Senator Sheridan Downey, of California, covering the need for studying post-war conditions and their relation to industries such as roadbuilding. More definite comments relating to the economics of roadbuilding were presented by Miller McClintock, director, Bureau for Street Traffic Research, Yale University, who stressed the point that lack of definite information on the total public benefits from road construction presented a major difficulty in the industry's struggle to secure necessary funds for needed improvements to the national highway system.

R. M. Smith, deputy minister, Department of Highways, Toronto, Canada, outlined some of the highway building problems faced by Canada, and described the "Queen Elizabeth Way."

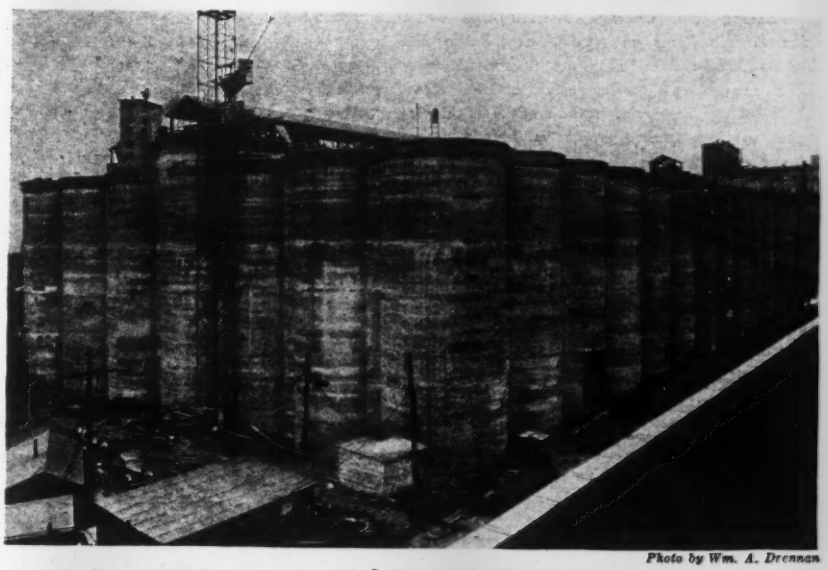


Photo by Wm. A. Brennan

Built in 105 days to hold 6,000,000 bushels of grain

Designed for long time storage of grain, the new 6,000,000-bu. concrete elevator erected at Buffalo, N. Y., for Cargill, Inc., is one of the largest of its kind in the country.

Using slip-form construction, elevators were built in three separate units. Each unit with a capacity of approximately 2,000,000 bu. was filled as finished. There are 56 silos, the six center ones have a capacity of 750,000 bu. each, while the remaining bins each hold from 50,000 to 100,000 bu.; bins in the average commercial elevator are said to have a capacity of 40,000 bu.

Test piles were driven Sept. 1, 1940, and the first unit was completed and filled Nov. 1, the second unit Nov. 15, and the third and final unit Dec. 15. The cost of the project was approximately $1,300,000.

H. G. Onstad Engineering & Construction Co., Chicago, was general contractor with Thomas Smith, project engineer, and John Stock, construction superintendent.

Photo by McLaughlin Air Service

Lift span put in service on New Jersey truck route

Principal unit of a 2,004-ft. bridge over the Passaic River on New Jersey Route 25 is the 332.5-ft. lift span put in service Jan. 27. The bridge carries much of the New York-bound commercial traffic from New Jersey and southern points which is barred from the Pulaski Skyway.

The new span, which will have a vertical clearance of 40 ft. when closed, replaces a low swing bridge, and is expected to reduce the number of bridge openings by 80 percent. A total vertical clearance of 135 ft. is provided by the new span which was assembled on falsework, then floated into position in September. (ENR Sept. 19, p. 375).

The new and old bridges are so close together that the original structure cannot be opened for navigation when the lift span is at roadway level. To put the new road in operation without stopping navigation it was necessary to halt traffic over the week-end, open the old swing bridge and cut several panels from it before lowering the new span to the approach level. The old span and its foundation will be entirely removed.

The bridge was built by the New Jersey highway department, Morris Goodkind bridge engineer and A. E. Lee resident engineer. Ash-Howard-Needles & Tammen designed the lift span. Foundation work was done by Senior & Palmer, New York, on the main piers and Ole Hansen of Bentnor, N. J. on the approaches. Steel erection was carried out by American Bridge Co. and deck concrete was placed by La Fera-Grecco Constr. Co., Newark.

Full-time secretary for equipment distributors

The Associated Equipment Distributors, meeting in New York this week, announced substantial increases in both distributor and manufacturer members and accentuated its increasing organizational activities by appointment of its first full-time secretary. Meetings stressed the benefits of local group organization within the national body, the value of statistical information, supplied by technical publications and other sources, and the effect of the highway program in preventing a recession in construction.

Featured at the meeting were a new uniform lease contract with a purchase option rider and a schedule of rental rates suggested as a guide for construction equipment hire. Monthly, weekly and daily rates are given for one shift with a recommendation to increase by 50 percent for two shifts and 100 percent for three shift operation. The schedule was prepared by the Rental Committee of the A.E.D. of which Eldon M. Farnum, Geo. F. Smith Co., Inc., St. Louis, was chairman. Copies may be obtained from him for $1.

Wm. G. Morgan of the Geo. F. Smith Co., St. Louis, Mo., was elected president; T. W. Harron, San Francisco, and E. P. Phillips, Richmond, Va., vice presidents; and R. R. Nixon, Chattanooga, the retiring president, treasurer. The new national secretary is Carol Winchester, who will maintain offices in the National Press Building, Washington.

• • •

Open Grand River spillway to save $200,000 bridge

Spillway gates of the Grand River Dam, near Vinita, Okla., at one time the center of controversy between Oklahoma's Governor Philips and federal agencies, were opened Jan. 18 on advice of John M. Carmody, Federal Works Administrator at Washington. Before the gates were opened, the lake behind the huge structure had encircled the town of Grove, Okla., and was threatening to cover a $200,000 state bridge on U. S. Highway 60. Chairman Ray McNaughten, Grand River Dam Authority, ordered eight of the 21 gates opened after Mr. Carmody had advised that such action on a day-to-day basis would not be objectionable. Earlier in the day (Jan. 18) the rising reservoir threatened U. S. Highway 59, Grove's last outlet to the rest of Oklahoma, and forced the contractor on a bridge near Wyandotte to move his equipment to higher ground.

• • •

Tacoma narrows bridge authority sued

The Pacific Bridge Co., San Francisco; General Construction Co., Seattle, and Columbia Construction Co., Portland, Ore., who held the contract for construction of the recently collapsed Tacoma Narrows Bridge, have brought suit in the Washington state supreme court to compel the Washington State Toll Bridge Authority to pay $619,915 for work done on the bridge. The case will be opened for hearing Jan. 24.

James A. Davis, acting state highway director, states that the bridge authority had not received the final grant from the Public Works Administration, and as a consequence final payments had not been made to the contractors.

• • •

Federal aid for N. Y. defense roads urged

Declaring an adequate military or defense highway system in the state of New York to be a vital part of any preparedness program, a Joint Legislative Highway Survey Committee, in an interim report to the New York legislature, has urged that federal funds be made available on a large scale for defense roads.

Trends and technique discussed at 35th Paving Brick Assoc. meeting

Major individual subject of interest was the recent development in the use of reinforced and monolithic brick paving construction. Projects in Ohio and Illinois described

The National Paving Brick Association devoted most of its 35th annual meeting at Toledo, Ohio, Jan. 15-17, to a discussion of the recent developments in brick paving, particularly reinforced brick and monolithic brick construction. Recent projects of these two types, in Illinois and Ohio, respectively, were described. Other features of the three-day session included talks by Perry A. Fellows, chief engineer, WPA, who told of WPA in national defense; a summary of the current improvement of Michigan, Woodward and Gratiot avenues, Detroit, by G. Donald Kennedy, highway commissioner of Michigan; some advice on association advertising and publicity by J. O. Peck, director of research, McGraw-Hill Publishing Co.; and a description of the brick-paved Queens-Midtown tunnel in New York by D. G. Baillie, Jr., New York Tunnel Authority.

Roy L. Phillips, city engineer of Meadville, Pa., jolted the placid tempo of one session with some pertinent questions concerning brick pavement. Though Meadville streets are almost exclusively brick surfaced, and despite 30 years of experience with brick paving, Mr. Phillips claims that he doesn't know the answers, and pleaded with manufacturers, the association and the experts to do the necessary research to find them. He started in with the subgrade, pointing out some absurdities in prevailing subgrade preparation, such as drainage in tight soil, and turned to base stabilization as a possible cure for most subgrade troubles. Yet, he maintained, some neutral agency, not identified with stabilizating materials, must work out the procedure best suited to brick pavements. Even the use of concrete, Mr. Phillips said, which is generally accepted as the best base for brick, brings up questions of thickness, mix, expansion joints and other perplexing problems. He cited one example of a continuous brick-surfaced road built on a 1:3:6 concrete base 5 in. thick on one side of a city line, and on an 8-in. thickness of 1:2:4 concrete on the other side. Both bases couldn't be right for that particular job, he reasoned, and no one could tell him which was correct. Base design needs a more scientific approach than it has received in the past.

T. W. Kinnear, chief engineer of construction, Ohio Department of Highways, described the revival of monolithic brick pavement in Ohio that started in 1938. In this method of construction the bricks are laid in a fresh concrete base, vibrated into place and filled with cement grout, forming a monolithic structure. A year ago the design was changed to add a special edge block forming a lip curb.

MURRAY D. (Pat) VAN WAGONER, new governor of Michigan and former state highway commissioner, chats with C. C. BLAIR, president of National Paving Brick Assn.

A couple of hustling young engineer-secretaries present were WM. H. CULLIMORE (left) of the National Paving Brick Ass'n. and V. K. GAMBLE of Ohio Paving Brick Assn.

M. E. O'Brien, Springfield, Ill., and E. V. Poston, president, Postin-Springfield Brick Co., told of a mile-long project built for the state of Illinois last summer in which reinforced brick surfacing was used. Experimental sections of this type of paving were built in Illinois in 1931 and again in 1937. From observation and study of the two experimental sections, the state decided to build a mile-long section in 1940. In this section an improved type of brick, 8x8x¾ in. longitudinal fiber, with brushed top, and including spacing lugs serving also as bar supports were used. On part of this project, which is 22 ft. wide, the bricks were laid in a sand bed placed directly on the subgrade. On another stretch the pavement was 40 ft. wide and the bricks were laid on a sand bed of varying thickness placed on the subgrade, except that the center 18 ft. was an old concrete foundation from which the brick surface had been removed. On the balance of the project, 22 ft. wide, a 2-in. concrete base was laid on the subgrade, and before the concrete was set, bricks were placed directly on the foundation. On all of the project a grout filler, of a consistency permitting filling of the joints and encasing of the reinforcing bars, was used.

H. Z. Schofield, research director of the association, described a new sponge rubber roller developed for the application of a separating agent to the surface of brick pavement to permit easy removal of excess joint filler. He stated that drawings and a description of the roller may be obtained from the Ohio Paving Brick Association, Hartman Building, Columbus, Ohio.

The meeting was conducted under the general direction of C. C. Blair, president, and William H. Cullimore, engineer-secretary of the National Paving Brick Association, in cooperation with the Ohio Paving Brick Association.

• • •

Lincoln Tunnel work to be resumed this summer

Work will be resumed on the North tube of the Lincoln Tunnel connecting New Jersey with New York City early this summer, according to an announcement Jan. 18 by Frank C. Ferguson, chairman of the board of the Port of New York Authority.

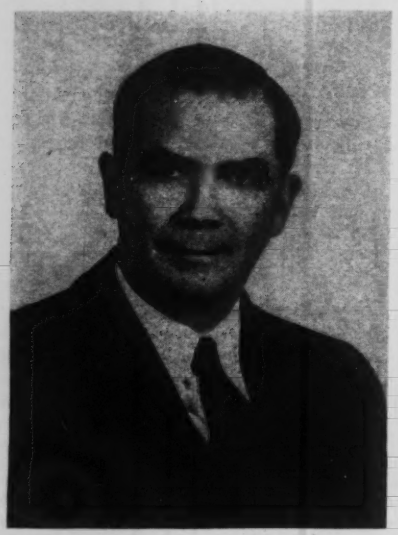
The steady increase in the use of the south tube (completed Dec., 1937) along with pending improvements in the New Jersey connecting highways, is said to have lead to the decision to resume construction. About 3 years ago after the bore and other rough work on the North tube had been finished from the Weehawken plaza on the New Jersey side to a point just west of 11th Ave., in Manhattan, New York, construction was suspended.

First contract to be awarded will provide for the extension of the bore from its present Manhattan terminus to the site of the plaza at a point between 10th and 11th Aves., and 39th and 40th Sts. Later contracts will provide for the tiling, paving, electrical and other equipment installation, ventilation buildings on both shores of the Hudson River, and for the Manhattan plaza.

Specifications are now being drawn and with work to get under way by early summer, and it is anticipated that the north tube will be completed by the end of 1942. The estimated cost of the work yet to be done is $6,000,000.

Silver anniversary meeting of Colorado engineers

The Colorado Society of Engineers, which is one of the largest state engineering organizations in the country, held its silver anniversary convention at Denver, Jan. 10-11. Approximately



Ralph N. Tracy
New president of Colo. Soc. of Engrs.

1,200 members of the organization representing all of the various branches of the engineering profession attended.

With nine charter members, the society held its first meeting in 1916; originally called the Colorado Society of Civil Engineers, the name was changed in 1917.

The society was organized primarily to fight the practice in Denver of employment agencies charging enormous fees for engineering positions. The society was instrumental in having an engineer's licensing law passed and since its inception has served as a clearing house for engineers, having in the past 25 years filled about 3,000 positions.

The following officers were elected for the year 1941: Ralph N. Tracy, chief engineer, Denver office of Hardesty Mfg. Co., president; R. W. Lindsay, chief engineer of Mountain States Telephone & Telegraph Co., vice president; C. M. Lightburn, valuation engineer, Denver & R.G.W. Ry., secretary-treasurer. Directors elected for the ensuing year include: W. B. Cheek, district engineer of Western Portland Cement Assoc.; Alfred Stiefel, assistant chief engineer of the Colorado Water Conservation Board; Roy Klein, senior highway engineer, U. S. Public Roads Administration; Art Hewitt, assistant engineer, Colorado State Highway Department; Fred C. Carstarphen, consulting engineer of Denver; and Charles Davis, city sanitary engineer of Denver.

JOBS OF THE WEEK

AIR BASE, Puerto Rico
McCloskey & Co., Philadelphia, Pa., has received contract for construction of an air base at Borinquen Field, for U. S. Engineers, Washington, D. C. Cost estimated at $4,763,750.

MILL, Coatesville, Pa.
Arthur C. McKee & Co., Cleveland, O., has been awarded contract for constructing an additional mill for Lukens Steel Co., Coatesville, Pa. Estimated cost $2,100,000.

CHEMICAL PLANT, Freeport, Tex.
The Austin Company, Cleveland, O., was awarded contract for construction of a chemical plant for extracting magnesium from gulf waters by Dow Chemical Company, Midland, Mich. and Freeport, Tex. Work includes plant building, power plant, warehouses, shops, etc. Estimated cost is $2,100,000.

PENSTOCKS, California
Western Pipe & Steel Co. of California, San Francisco, Calif., has been awarded contract for construction of four penstocks for Shasta Dam, Central Valley Project by the U. S. Bureau of Reclamation, Denver, Colo., at a cost of $1,587,000.

NAVAL ORDNANCE PLANT, Canton, O.
Rust Engineering Co., Pittsburgh, Pa., has been awarded general contract to construct four major buildings for naval ordnance plant by Westinghouse Electric & Mfg. Co., East Pittsburgh, Pa., costing $2,225,000. Seven thousand tons of steel will be supplied by Bethlehem Steel Corp., Bethlehem, Pa. Total cost of plant is $16,575,000.

AIRPORT, Jackson, Miss.
M. T. Reed Construction Co., Belzoni, Miss., has received contract from U. S. Engineers, War Department, to construct hangars, shops, administration building, etc., at local airport. Cost is estimated at $1,377,000.

PLANTS, Indiana and Illinois
The Studebaker Corp. has received contract from the War Department to erect assembly plant at South Bend, Ind.; a feeder plant for gear manufacture at Fort Wayne, Ind., and a feeder plant for manufacturing connecting rods at Chicago. Total cost of the three projects estimated at $39,740,836.

AIRPLANE MOTOR PLANT, Paterson, N. J.
Wright Aeronautical Corp., Paterson, N. J., has received contract from the War Department to construct additional plant facilities. Project will cost $1,500,000.

RESIDENCES, South San Francisco, Calif.
S. G. Lodato and A. J. Eschelbach, South San Francisco, Calif., will construct 230 homes in the Beresford Area, by day work. Estimated cost $1,500,000.

WATER SYSTEM, Decatur (DeKalb County), Ga.
DeKalb County will construct waterline from Chattahoochee River to Government Honor Farm at Panthersville, Ga. and to Government supply depot at Conley, Ga. by WPA labor. Work includes filtration and treatment plant. Cost is estimated at $1,800,000. H. Weaver is superintendent of DeKalb County waterworks.

BAG LOADING PLANT, Charlestown, Ind.
Winston Bros. Co., Minneapolis, Minn.; C. F. Haglin & Sons, Inc., Minneapolis, and Missouri Valley Bridge & Iron Co., Leavenworth, Kan., have received contract for constructing a bag loading plant, and installation of equipment for the War Department, Washington, D. C., cost estimated at $15,227,080.

HOUSING, Cairo, Ill.
Henke Construction Co., Chicago, Ill., has been awarded contract for constructing Pyramid Courts Housing Project and Elmwood Place Project for Alexander County Housing Authority, Cairo, Ill. Cost of both projects estimated at $1,248,420.

TURBO SUPER CHARGER PLANT, Everett, Mass.
Turner Construction Co., Boston, Mass., was awarded contract for constructing a 1-story, 400x500-ft. and 80x300-ft. plant of brick and steel construction for turbo super charger production for General Electric Co., Lynn, Mass., estimated cost $5,873,800.

TELEPHONE CABLES, Colorado to California
American Telephone & Telegraph Co., New York, N. Y., laying underground telephone cables between Denver, Colo. and Sacramento, Calif., by own forces. Project cost estimated at $12,000,000.

DEPARTMENT STORE, Pittsburgh, Pa.
J. M. Baldwin, Pittsburgh, Pa., has been awarded contract for constructing a 2-story and basement, 139x239-ft. reinforced concrete department store and service station, for Sears Roebuck & Co., Pittsburgh, Pa. Estimated cost $1,000,000.

NOTE—Additional bidding and contract news on over 800 projects large and small appear in the Construction News section beginning on page 100.

WASHINGTON HIGHLIGHTS

RELOCATION or alteration of bridges in the Tennessee Valley area resulting from construction of TVA reservoirs would be paid for by TVA except insofar as the changes actually benefited the bridge owner under a bill now awaiting action in the Senate committee on agriculture. This would bring TVA practice into conformity with the new policy established by Congress last year for navigable rivers generally.

PUBLICATION of regulations governing the coordination of defense housing (*ENR*, Jan. 16, p. 69) reveals that Housing Coordinator Palmer's powers over the housing program are very concrete and detailed. All housing projects, under the various laws governing defense housing require Presidential approval. The regulations provide that before the President approves any project it shall be submitted to the coordinator who shall make recommendations to the President as to the method of financing to be followed, the agency to do the work, the character of the project, and the operation and management plans. Thus, in effect, Palmer's decision on these points is final except by appeal to the President. Moreover, Palmer is to pass upon the standards of design, facilities, operation and rent levels, and the labor standards adopted by each housing agency.

AN ARKANSAS VALLEY Authority similar to the TVA with jurisdiction over the Arkansas, St. Francis, Red, and White River basins would be set up under a bill which has been introduced into Congress and is now in committee.

UNLESS THE PRICE of lumber drops quickly to a level which will bring No. 2 Southern Pine, now over $31, to something in the neighborhood of $25, Price Commissioner Henderson will recommend price fixing to the War Department. Henderson told the lumber industry defense committee that he has had "all of the arguments, excuses and explanations that I want, and a damned sight more than I need."

What will be done, if Henderson's recommendation should be accepted, is the fact that the Quartermaster Corps will offer to buy lumber at a price it considers reasonable. If no lumber is forthcoming at that price, the Secretary of War, under the draft bill, may order a supplier to furnish lumber at the price. If the supplier refuses, he can be sent to jail and his business be taken over (at a fair rental).

This is the closest to a crack-down that any price issue has yet come. Lumber has been the big failure in the administration policy of talking prices down rather than taking drastic action.

Photo by McLaughlin Air Service

Tanks for an aggressive attack on pollution

Soon to be completed is the Jamaica sewage treatment works, one of the major units in the New York City program for pollution abatement in its harbor waters. This 65,000,000-gpd. activated sludge plant will serve the Jamaica Bay area in the southeastern section of Queens borough. Its total cost will be about $6,000,000.

Facilities for the removal of grit and screening of coarse solids have been operated at the site for some time. The new construction includes: a battery of rectangular tanks for aeration; circular settling tanks with sludge scrapers; two small sludge concentration tanks; and 12 covered sludge digesters. The sludge gas generated and stored in the latter tanks will be used to operate internal combustion engines, which will supply plant power.

One of the problems involved in the construction of this plant was the stripping of marsh muck over a 12-acre section of the site. From 2 to 6 ft. of muck deposit was removed and this was replaced with earth fill.

General contractor on the job is Geo. F. Driscoll Co., Brooklyn, N. Y., who sublet the concrete work to Moccia Construction Corp., Brooklyn. Design and supervision of the plant is under the jurisdiction of the New York City Department of Public Works. (See ENR Oct. 10, 1940, p. 461 for construction details.)

• • •

Ohio River pollution study nears completion

Biggest stream pollution study ever undertaken, the Ohio River survey, may be finished about a year earlier than anticipated with a final report available soon after July 1, 1941. This cooperative study of stream uses and abuses being made by the Public Health Service and the Corps of Engineers, assisted by several state health agencies, was originally planned to cover a three-year period. (*ENR*, May 23, 1940, p. 716, and June 20, 1940, p. 858.)

Field work has been speeded up to such an extent that these studies will be terminated at the end of March, according to Senior Sanitary Engineer H. R. Crohurst of the U. S. P. H. S. Of the laboratory studies, there remains the collection of data indicative of the effect of increasing flows along the river in the upper and lower sections, following the low stages of the past summer and fall, special short studies of taste and odor troubles along the Mahoning and Kanawha rivers, and limited field laboratory tests in the vicinity of the larger communities in the Cumberland and Tennessee River basins.

Field investigations of water supply and sewage disposal conditions were about 90 per cent complete on December 31 and the industrial waste studies were 78 per cent finished; it is expected to complete these by the end of March. Studies of water-borne disease, both in the laboratory and of outbreaks of gastroenteritis in the field, may be continued over a longer period, to be made the subject of a separate report.

Fast work on plane plant In spite of severe mud

James Stewart & Co. ahead of schedule on 23-acre size building near Dallas during period of record rainfall

Although handicapped by severe mud conditions resulting from a record period of heavy rain, James Stewart & Co. is ahead of schedule on construction of the $7,000,000 plant being built for North American Aviation of Texas near Dallas. The main plant covers 1,000,000 sq.ft. (23 acres) of floor area. It will be a complete "blackout" structure and sets a new record size for windowless buildings. Complete fluorescent lighting and air conditioning will be provided for 24-hr. operation. The plant is located at Grand Prairie on the main line of the Texas and Pacific Ry.

Working on a close construction schedule which allows only 110 working days for completion of the entire plant, the contractor has overcome conditions of unusual severity during early stages of the job, putting in footings and erecting steel over the 23-acre site working in a morass of gumbo which developed from a rainy period extending over several weeks. Excavations of the site included the removal of top soil to relatively firm material, followed by the excavation for individual footings. A gravel backfill replaces the excavated material and forms a base for the 6-in. concrete floor. The 4,000 tons of structural steel, with roof trusses and purlins delivered in fabricated units, were erected by crawler crane. Miles of trenches for utilities were required in the plant area and these presented particular problems due to the mud.

The structure will be the largest windowless building constructed to date and the design provides for minimizing and localizing any damage from air bombing. The roof will be camouflaged with features representing a golf course. The design includes the use of special type cellular steel side walls and a similar design of roof covering using cellular steel with proper insulation.

The contractor began operations on the site Nov. 15 and the present schedule indicates completion about Mar. 15, as compared to a contract time of 110 working days.

The plant was designed by J. Gordon Turnbull, consulting engineer, with Allen & Kelly, associate architects. Construction operations are being directed from the Dallas office of James Stewart & Co., with Roger Peabody in charge. Joseph Cunningham is general superintendent and J. E. Fry engineer for the contractor.

Aerial Photo Service

Occupying 23 acres, this plane plant near Dallas, Tex. has been erected in fast time during a period of record rainfall, which developed severe mud conditions as shown below.

Photo by Elwood M. Payne

Bids to be opened for Colorado water tunnel

Bids will be opened Feb. 3, at the Denver office of the U. S. Bureau of Reclamation, for the third unit of the 13.1-mi. tunnel now being driven under the Continental Divide between Grand Lake and Estes Park in Colorado. This construction is part of the $54,000,000 Colorado-Big Thompson irrigation and power project.

The new unit will be 7,000 ft. in length and be driven from the end of the first 8,000-ft. section now nearing completion at the eastern portal of the tunnel by the S. S. Magoffin Co. of Englewood, Colo.; the latter section, costing $471,000, is expected to be complete by the middle of February. The 6,000-ft. section at the western portal is being constructed by the Platt Rogers Const. Co., Inc., Pueblo, Colo., at a cost of $389,370.

Contract for the new 7,000-ft. section will include the concrete invert lining and in addition 7,639 ft. of the invert of the 8,000-ft. section of the eastern portal.

C. H. Howell is construction engineer for the U. S. Bureau of Reclamation and is directing all work in connection with the tunnel.

• • •

Havana students win engineering award

Two engineering students at the University of Havana have been awarded the $1,000 E. A. Emerson engineering award sponsored by Armco International Corp., subsidiary of American Rolling Mill Co., Middletown, Ohio. Luis Perez Daple and Rene Montero Pardo, the winners, collaborated on their entry. The contest was conducted to encourage closer technical relations between the Americas through development of a standard vocabulary of engineering terms in the Spanish language.

• • •

Damage suits of $121,844 filed against Rochester

As a result of the recent pollution of the Hemlock water supply with Genesee River water, the city of Rochester, N. Y., faces damage suits totaling $121,844. Workmen accidently opened a valve, Dec. 11, which permitted Genesee River water to enter the safeguarded municipal water supply causing the pollution (*ENR*, Dec. 19, 1940, p. 805).

Of the 28 claims filed Jan. 10, the dead line according to law for claims to be filed, only one was based on the allegation that typhoid fever had resulted from drinking the contaminated water; other claims in general were based on allegations that stomach illnesses had been caused by the polluted water.

OBITUARY

FRED G. CUNNINGHAM, consulting engineer, died at Fairfield, Conn., Jan. 26. He was the last surviving partner of the engineering firm of Fuller & McClintock, Bridgeport, Conn. Mr. Cunningham was a consultant on the Bridgeport, Conn. sewage project.

E. RUSSELL ALLEN, civil engineer, died Jan. 26, at Baltimore, Md. Mr. Allen was a graduate of the University of Maryland in the class of 1926. He had been with J. E. Greiner Co., consulting engineers of Baltimore, since his graduation. At the time of his death was project engineer in charge of engineering and construction of the cantonment being erected at Ft. George G. Meade, Md.

FRANCIS JAMES NOONAN, former chief engineer of Division 10, Missouri State Highway Department, died Jan. 18 at Sikeston, Mo. Mr. Noonan was with the Missouri State Highway Department from 1920 to 1939. At the time of his death he was city engineer of Sikeston, and Dunkin county engineer.

THOMAS G. PIHLFELDT, engineer of bridges, Chicago, died Jan. 23 at the age of 82. Considered the inventor of the bascule type of lift bridge, 56 of which had been constructed under his direction, he served the city for 52 years. Born in Vadso, Norway, he received his engineering education in the technical schools of Hanover and Dresden.

BENJAMIN THOMAS CLARK, chief engineer of the Greenville, N. C., water and light department from 1919 to 1927, died Jan. 16. Mr. Clark was 54.

F. X. ERNEST LOIGNON, consulting hydraulic and civil engineer, died Jan. 18 at Montreal, Canada. He was in his 76th year. Mr. Loignon received his civil engineering degree at the Cole Polytechnique of Montreal in 1888, and later studied in Paris and Switzerland, specializing in reinforced concrete design, and in 1932 received a D.Sc. degree from the University of Montreal. He designed and constructed the Montreal harbor bridge, the Wellington vehicle tunnel, Temiskaming dam and power development.

W. L. WEBB, civil engineer, of Philadelphia, Pa., died Jan. 24. Mr. Webb had taught engineering at Cornell University and held the post of assistant professor of civil engineering at the University of Pennsylvania.

He served as a geological surveyor with the U. S. Engineer Corps, was associated with the Coast Survey and from 1917 to 1920 was a major of engineers in the Army.

WILLIAM A. MCTIGHE, formerly construction engineer at Little Rock, Ark., for the eastern division of the Arkansas Highway Department, died at Memphis, Tenn., Jan. 18.

J. ANDY TEAL, WPA area supervisor of sanitation, died at Chesterfield, S. C., Jan. 18. Mr. Teal was former county engineer and resident engineer for the South Carolina State Highway Department.

EDWIN N. SEYMOUR, vice president of the MacDougald Construction Co., Atlanta, Ga., died Jan. 21. Mr. Seymour was a graduate of the University of Mississippi in civil engineering, class of 1913. He was engineer for the Georgia State Highway Department for nine years before joining the MacDougald Construction Co. in 1937.

PORTER WILLIAM GIFFORD, president of Gifford-Hill & Co., Inc., Dallas, Tex., died Jan. 8.

CHARLES O. CRAWFORD, SR., division engineer of terminals for the L&N Ry. died recently at Bay St. Louis, Miss.

P. S. VAN NATTA, civil engineer of Casper, Wyo., died recently. Mr. Van Natta worked on many important railway projects, and at one time was assistant city engineer at Casper.

CONTRACTS AND CAPITAL

ENGINEERING CONSTRUCTION awards for the week total $98,834,000, a 57 percent increase over the corresponding 1940 week. This is the 22nd consecutive week in which current values have exceeded their respective totals of a year ago. The week's total, however, is 37 percent lower than that reported last week.

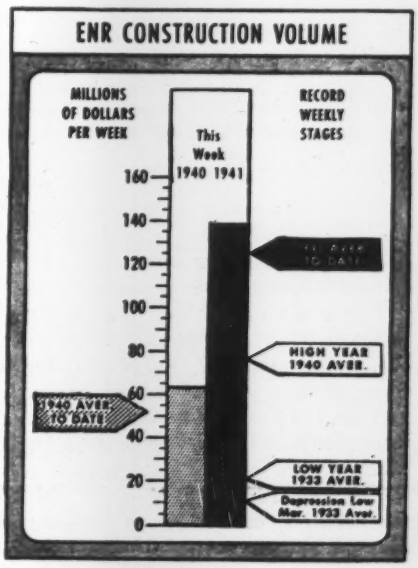
The construction volume for 1941 to date, $584,549,000, is 129 percent above the opening 5-week total for 1940. Private awards are 92 percent higher than in the 1940 period, and public construction tops last year by 150 percent as a result of the 839 percent increase in federal work.

Private awards for the week, are 10 and 12 percent higher, respectively, than a year ago and a week ago. Public construction is up 112 percent compared with last year, but 50 percent under last week.

In the classified construction groups, waterworks, sewerage, bridges, public buildings, and unclassified construction top their last year's totals; and waterworks, sewerage, commercial building and large-scale private housing, earthwork and drainage, and unclassified construction gain over last week.

New capital for construction purposes for the week, $11,849,000, is 71 percent lower than in the 1940 week. The current week's financing is made up of $8,228,000 in corporate security issues, and $3,621,000 in state and municipal bond sales.

New construction financing for the year to date, $93,988,000, is 18 percent under the $114,907,000 reported for the 5-week period a year ago.



CONTRACTS

(Thousands of dollars)

	Week Ending Feb. 1 1940	Jan. 23 1941	Jan. 30 1941
Federal	$7,570	$102,409	$27,947
State & Municipal	21,454	20,645	33,688
Total public	29,024	$123,054	$61,635
Total private	33,918	33,120	37,199
TOTALS	$62,942	$156,174	$98,834
Cumulative 1941	(5 weeks)		$584,549
1940	(5 weeks)		$254,919

Note: Minimum size projects included are: Waterworks and waterways projects, $15,000; other public works, $25,000; industrial buildings, $40,000; other buildings, $150,000.

NEW PRODUCTIVE CAPITAL

	Cumulative 1940 5 weeks	1941 5 weeks
NON-FEDERAL	$114,907	$93,988
Corp. Securities	13,398	33,282
State & Mun.	56,249	47,043
U.S.H.A. loans	45,199	12,043
R.F.C. loans	61	1,620
FEDERAL	.....	.....
TOTAL CAPITAL	$114,907	$93,988

FHA MORTGAGES

	Week Ending Jan. 27 1940	Jan. 18 1941	Jan. 25 1941
Selected for appraisal	$16,493	$19,766	$20,864*
Cumulative 1941	(4 weeks)		$73,394*
1940	(4 weeks)		$61,120

* Subject to revision.

ENR INDEX NUMBERS

Index Base=100		1913	1926
Construction Cost	Jan. '41	249.89	120.03
Building Cost	Jan. '41	207.94	112.46
Volume	Dec. '40	344	151

Comment and Discussion

Readers' opinions on matters that concern engineers and contractors

Contractor-WPA Work

Sir: The article by D. C. Greer regarding Contractor-WPA work in Texas (*ENR*, Dec. 5, 1940, p. 737) states: "The fact that the number of bids received on State Highway Department-WPA projects is equal to, or higher than, the average number of bids received for either straight state or regular federal-aid projects indicates that Texas contractors look with favor upon constructing this kind of project."

I believe this entirely omits the contractor's view point of this matter, as it is my observation over a period of years, that the number of bids submitted on any given job is dependent, almost entirely, only upon the amount of work under contract at the time. In other words, it depends upon whether contractors are or are not busy.

C. C. Cook
176 West Adams St., Chicago, Ill.

Stability Formula For Tacoma Bridge

Sir: The failure of an important structure such as the Tacoma Bridge, the design of which incorporated the best of current knowledge and technique, cannot fail to be disturbing to structural engineers responsible for other work until such time as the cause of the failure is analyzed and better methods of design are evolved. The writer has recently been making theoretical and experimental studies of related stability problems in connection with the work of the Bureau of Reclamation and it occurred to him that it would be of interest to apply the methods he is using to an analysis of the failure of the Tacoma suspension bridge.

The solution of the resulting formula, necessarily using somewhat rough determinations of the constants from the limited published data on the Tacoma Bridge, gives a critical load for the stability of the wind bracing system sufficiently close to that known to exist at failure to make the results of interest to other engineers. In addition, since the solution is of a more general nature than has previously been published it may be applied to other bridges, and the importance of the various terms contributing to stability in the various possible modes of torsional oscillation can be evaluated.

The equation for critical stability in the r'th mode of the floor system acting with the stiffening trusses to form a horizontal wind girder is

$$\frac{(DFL^2)^2}{MEI_2}P_r^2 + Tb^2P_r - k_rb^2 - \left(\frac{\pi r}{L}\right)^2 GI_r = 0 \quad \ldots\ldots (1)$$

where

P_r = critical dynamic wind pressure, lb. per sq. ft. in the r'th mode.
r = mode of torsional oscillation: 1, 2, 3, etc.
E = modulus of elasticity, lb. per sq. ft.
M = a constant varying with type of construction (see below).
L = span between towers, ft.
T = twist factor due to lift.
I_2 = moment of inertia of stiffening trusses about the horizontal neutral axis, ft.^{4}
F = projected area of suspended structure per linear foot on vertical plane, ft.^{2}
D = drag coefficient.
b = width of bridge, ft.
GI_T = torsional rigidity of suspended structure, lb. per sq. ft.
k_r = twist rigidity of cable suspension, varying according to the "mode of tortional oscillation," lb. per sq. ft.

The first term of Eq. (1) is the influence of drag on the floor system. The drag coefficient D includes the effect of the rear truss and varies with the kind of member and solidity ratio. It may be determined from wind tunnel tests, but probably ranges from 1.5 to 2.5. M varies with the partition of wind load between the deck and the main cables and the general construction of the bridge but can usually be taken as 250 for suspension bridges.

The second term is the twist effect due to the lift component of wind pressure.

The third term is the stabilizing effect of the cable. For oscillation in the first mode, $k_r = k_1 = \frac{40\,f^2\,AE}{3L^4}$ which takes into account the elastic stretch of the cables. For the second mode, $k_r = k_2 = \frac{w}{f}$, which involves only the geometric shape of the cables.

In these formulas

f = sag of cables, ft.
A = sum of area of two cables, sq. ft.
w = weight (lb.) of total structure per ft.

Numerical analysis shows that for a suspension bridge torsional oscillation in the second mode will always give the critical condition.

The fourth term represents the torsional rigidity of the deck. Without a boxed-in section this usually will be negligible.

The critical wind velocity in miles per hour may be found from the following equation:

$$V = \sqrt{\frac{P}{0.00256}} \quad \ldots\ldots (2)$$

Eq. (1) is applied to the Tacoma Bridge using data taken from *Engineering News-Record*, Nov. 21, 1940: $M = 250$; $T = 1.25$; $E = 30 \times 10^6 \times 144$, lb. per sq. ft.; $f = 232$ ft.; $L = 2{,}800$ ft.; $F = 8$ ft.^{2}/ft.; $I_2 = 24.1$ ft.^{4}; $b = 40$ ft.; $A = 3.14$ sq. ft.; $w = 6{,}400$ lb. per lin. ft.

From these values $k_1 = 158.4$ and $k_2 = 27.6$.

Taking a value for the drag coefficient $D = 2.0$ and neglecting the fourth term of Eq. (1), since the torsional rigidity of the deck in this structure is small, the equation for the critical load under first mode of torsional oscillation ($r = 1$) is:

$604\,P_1^2 + 2{,}000\,P_1 - 253{,}440 = 0$

or $P_1 = 18.9$ lb. per sq. ft.

For the second or principal mode, the condition under which the bridge failed,

$604\,P_2^2 + 2{,}000\,P_2 - 44{,}160 = 0$ or

$P_2 = 7.1$ lb. per sq. ft.

Substituting $P_2 = 7.1$ in Eq. (2), V = 52.7 m.p.h., which compares with the 42 m.p.h. estimated at the time of the accident.

It is also interesting to note that for a pressure of 6.8 the theory gives a period of oscillation in the second mode of 12 seconds.

A consideration of Eq. (1) indicates that the most effective way of increasing the critical wind load is to provide torsional resistance. Computation indicates that with a boxed-in section only nominal steel is required to increase the critical wind load many fold.

It is of course important that the critical wind pressure should be held well above the maximum existing pressure to give sufficient safety factor and to avoid violent torsional oscillations in the second mode. The complete theory upon which the above formulas are based is available in the Bureau of Reclamation's photoelastic laboratory and will be published as soon as feasible.

J. H. A. BRAHTZ
In charge of Photoelastic Laboratory
U. S. Bureau of Reclamation
Denver, Colo.

For Better Soil Sampling

Sir: The special equipment and procedure described by F. B. Slichter in "A Non-Distorting Soil Sampler" (*ENR* Dec. 5, 1940, p. 60) is a distinct contribution to the problem of undisturbed sampling in borings. His method is unique in that it provides a means of eliminating all impact loads, which are commonly used for advancing both sampler and casing. The author's method of pushing the sampler into the soil in a fast continuous drive, and likewise advancing the casing, is a step in the right direction and should produce undisturbed samples of high quality.

A distinctly different but equally adequate method of advancing the casing and sampler has been used recently in the Providence U. S. Engineer District. The method was developed originally for use in obtaining undisturbed samples of cohesionless materials within 6-in. diameter borings. The method has worked so well that it has become standard practice within the district in sampling either cohesionless or cohesive materials.

The 6-in. casing, which is flush-jointed and provided with a shoe and cutting edge, is advanced in depth by jetting action supplied by three jet pipes located around the outside of the casing. Material rising within the casing, as the casing advances, is removed by a special hand-operated auger and controlled horizontal jet action. Sinking is facilitated by turning the casing by hand, which, with proper jet action on the outside, is not difficult.

To date depths of 50 ft. in cohesionless sand, and 90 ft. in silt and clay, have been reached, with possible maximum depths attainable by this method yet to be determined. By casing off with a 10-in. casing those strata from which it is not necessary to obtain undisturbed samples, skin friction on the smaller 6-in. casing is greatly reduced. Such materials, in New England valleys at least, consist of coarse sand and gravel with numerous cobbles and small boulders.

The sampler is advanced or pushed into the soil by a fast continuous drive, the power for which is supplied by a gas engine and a system of pulleys and rope. A particular advantage of the method described above is that it does not require any elaborate or expensive equipment, and can be used with any standard small boring outfit.

FRANK E. FAHLQUIST
Senior Geologist
U. S. Engineer Office
Providence, R. I.

Cavity Brick Walls

Sir: I have read with interest your article (*ENR*, Sept. 12, 1940, p. 332) concerning cavity walls, for in my country practically no building wall is made otherwise. In Holland, not only does a great part of the country lie below sea level but the weather is often very rainy. So we are obliged to build dry buildings and, according to our practice, there is no possibility to do it well without cavity walls.

The way followed in the Montclair, N. J., apartment house is not quite correct. The following details should be adhered to:

(1) All ties should be of single, galvanized, round steel, bent down in the middle, which, as stated in your article, is recommended by the English authorities.

(2) The outer side of the inner withe should be plastered, as the mason work goes on, with a cement-sand mixture of 1 : 2½. This work is done by the bricklayer with his bricklayer's tool. No smooth surface is obtained, nor needed.

(3) A single *solid leader should not be* used, and, if a solid connection between outer and inner withe is unavoidable, a lead slab is used to direct the moisture to the outer withe.

(4) No plaster is used in Holland on the outer face of the walls.

(5) No *watertight* plastering should be used on the inner wall face. A plaster of a very lean mixture of lime and sand should be used there. If a waterproof plastering should be applied on the inner face the natural moisture in the room is condensed on the walls, and, in the case of our spongy plaster the walls remain dry and the apartment healthy and clean.

(6) Brickwork on the outer wall face is, directly after completion of a few hours' work, scratched out, say 1 in. deep. Those spaces are later filled with a cement-sand mixture with only so much water as is necessary to obtain a putty thickness.

Our custom is not to use plaster on the outer face. Plaster work makes the work completely "dead" whereas our brick buildings are "alive" and lovely. Few of our buildings are built with brick walls as a filler between concrete; instead, the brick is a construction element. For higher buildings with heavy loads, the walls are composed of one full brick (20 cm.) inside withe and ½ brick (10 cm.) thickness outside. Such walls are of sufficient strength, although in our poor Rotterdam many thousands of buildings are crumbled to dust. The size of our bricks is 20x10x6 cm. Practically all bricks are of baked clay. Some are, according to the clay pits, of fine and beautiful appearance. Such fine bricks are naturally not cheap, but the more expensive bricks are used only on the outside (advance of cavity walls!) and of course only in higher-class buildings.

Perhaps it may interest you to know that we pay for normal brick about thirteen Dutch gulder per thousand bricks. In the baking process, bricks of different hardness come from the kiln. The hardest are used for pavement. Further hard quality is used for the first 2 ft. of wall height above floor level to prevent suction of moisture. Such bricks are laid in fat cement and sand mixture. Such hard bricks in cement become harder than concrete.

I do not know if it is possible in the United States to make such bricks as we use, although I assume it is. In other countries which are visited by us we Dutchmen are always horror-stricken by the dirty cemented buildings, whereas such fine and lovely work can be made without plaster.

If I have been successful in conveying some idea of Dutch brick practice I am glad because the articles that you publish help us.

J. NUNNIKHOVEN
Helmond, Holland, Oct. 17, 1940

EDITORIALS

VOLUME 126 NUMBER 5

January 30, 1941

A Challenge to Roadbuilders

HIGHWAY BUILDERS and construction equipment distributors are gathered in New York this week for the annual meeting of the American Road Builders Association. Seldom have they faced a year so full of uncertainties. The highway men know that much work is needed to bring their roads up to the requirements of an intensive program of military preparedness, but as yet they have not been told by Congress or by military authorities just what is going to be expected of them. Similarly, the equipment men see on one hand that priorities for military equipment may call for radical changes in their operations during the year, while on the other hand they may be called on for more than normal supplies of construction machinery to speed an intensified roadbuilding program. To both highway builders and equipment men the year stands as a challenge to their production ability. Past records make it clear that the challenge will be met with credit to all.

Still Better Equipment Needed

THE DISPLAY of construction machinery at last year's Road Show brought forth enthusiastic acclaim for the advancement that it recorded. But even before the new machines began working on pay jobs the designers who had seen the previews were finding further details to improve, and when the equipment went into the mud and rough of construction other suggestions were picked up by alert distributors and service men and passed back to the manufacturer. Today we have more than a hundred new machines, each described briefly in this issue, many of which are the fruit of constructive criticism of last year's equipment. This is as it should be; manufacturers and users alike profit from progressive improvement of construction equipment. But as 1941 opens some manufacturers report that defense orders have kept them from converting suggested improvements into new models. Doubtless this is to be expected, and there may be more of it in the future, but such freezing of designs should be resisted as vigorously as possible without delaying the production of machines required for current defense work. Construction will need the most rapid development possible in equipment to meet the labor shortages and higher costs that doubtless will come as the defense program rises to its peak, and should not be handicapped by lack of new machines in carrying forward its part of the defense program.

Civilian defense measures

ENGINEERS assume a new responsibility in this era of total war wherein civilians face the hazards of aerial bombardment. Added to the normal problems of providing the service facilities that are part of urban living, comes the further necessity for safeguarding structures and utilities. What should be done and how is a prime topic for discussion, as was evidenced most recently at the annual meeting of the American Society of Civil Engineers. There a committee on civilian protective measures reported on some of the matters that call for special engineering analysis; these included bomb-resistant structures, safeguards for water, sewage and power facilities, transportation problems and general emergency control. Quite properly now is the time for these matters to be discussed and carefully considered. But this is not the time to rush into action. The problem ahead is broad in scope, and eventually may call for the application of entirely new concepts in municipal planning and services. Hasty and perhaps expensive experiments may prove worthless and the inevitable reaction will be to retard rather than promote civilian defense measures.

Rebuilding a Ruin

AUSTIN DAM on the Colorado River of Texas had few rivals as the best engineering ruin in the United States when, two years ago, engineers began the latest and, it is hoped, the last attempt to make it hold water and resist floods. Its troubles started when its original builders mistakenly founded it virtually on the surface of the river bedrock, a limestone that was badly fractured and full of solution channels. Troubles grew into failures, each followed by rebuilding, but always without going deep enough into the principal seat of the trouble, the foundation. In pointing to the recent reconstruction, which included underpinning and high-pressure grouting of the limestone base, it would be a mistake to dismiss the earlier attempts as incompetent, however much they would deserve that description if carried out today. Rather, it is proper to give thought to the growth in construction ability and equipment that a half-

century has produced; in particular the development of new methods for subsurface exploration and foundation grouting that have provided modern engineers with a tool that makes easy a task that was once all but impossible. The present reconstruction of Austin Dam is a striking example of our present ability to utilize an initially poor foundation whenever better ones do not exist in a location where other conditions require a structure to be placed.

Power Along the Canadian Border

CLAIMING that electric power is needed for national defense, the President is moving toward starting the development of such power in the International Rapids of the St. Lawrence River without getting Canada to agree to a much-needed revision of the boundary water treaty of 1909. His legal advisers have told him that the power projects (which have been close to his heart since the days when he was Governor of New York) can be undertaken without the formality of a treaty, and he has vast funds at his disposal that can be used for anything that is held to be for national defense. Thus, unless Congress acts promptly to check such hasty action, this country may find itself launched into power development along the St. Lawrence and committed to large expenditures for those parts of the seaway that must be built concurrently with the power dams while still bound by the inequalities of the old treaty.

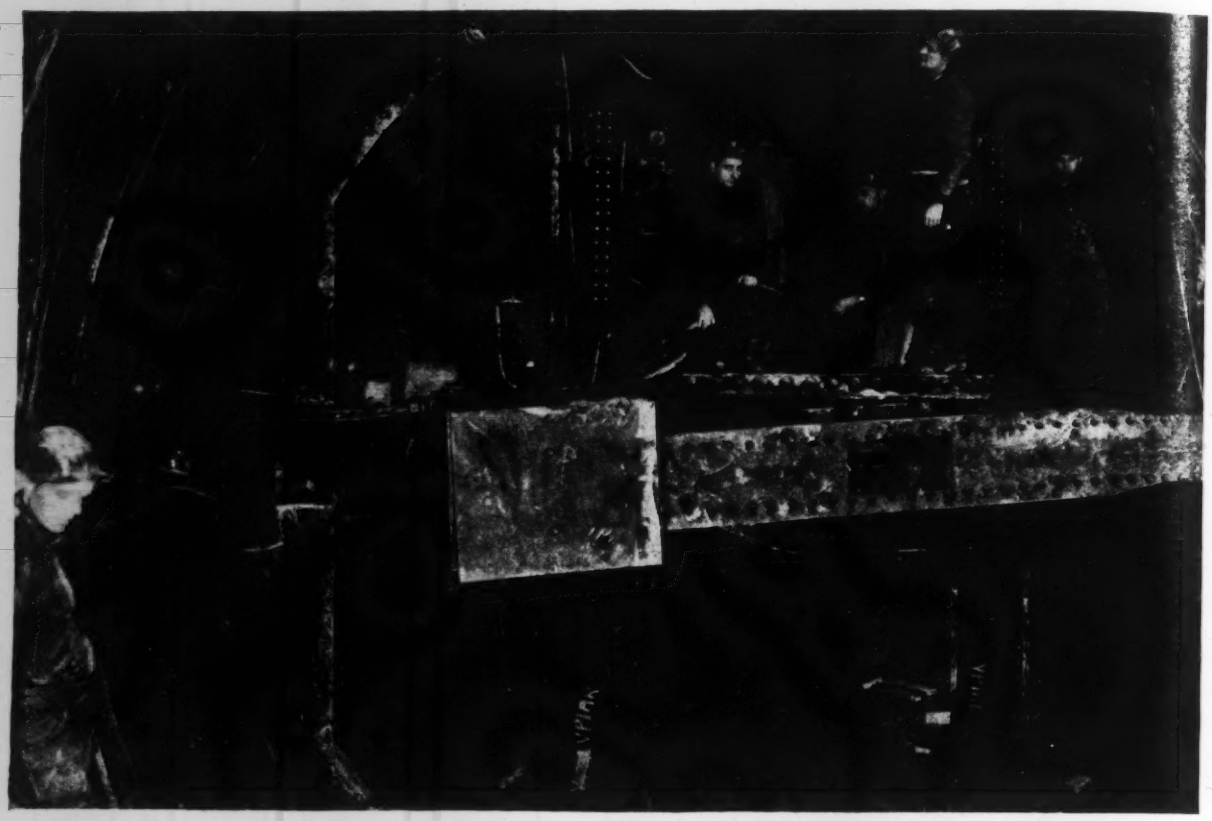
The 1909 treaty allocates 36,000 cfs. of water at Niagara Falls to Canada for power development, and only 20,000 cfs. to the United States. Though the treaty does not say so, this was the result of a tacit understanding between the negotiators that Canada should have more water to offset the Chicago diversion of 10,000 cfs. through the Sanitary Canal and because a considerable amount of power generated on the Canadian side was being exported to the United States. Now Chicago's diversion has been cut to 1,500 cfs. and there is no agreement that would prevent Ontario from cutting off the export of power to meet its growing needs.

These are the two major deficiencies of the 1909 treaty, but there are others needing prompt attention. Ontario's rights to use water diverted into Lake Superior from the Hudson Bay watershed need to be protected, remedial works at Niagara should be authorized, and provision should be made for larger diversions for power there if the remedial works live up to expectations.

BEFORE THIS COUNTRY takes any further action that will perpetuate the inequalities and deficiencies of the present treaty it should urge its neighbor across the border to agree to a new treaty that will put the following into effect: (1) Terminate the present inequitable water allocations for power development at Niagara Falls; (2) provide for the construction of remedial works above Niagara to check the rapid erosion of the Horseshoe Falls and spread the flow to other parts of the cataract; (3) authorize such future changes in power diversion above the falls as may be found possible after the remedial works are completed; (4) provide for further diversions of Hudson Bay waters into the Great Lakes on the Canadian side at such times as Canada may need them; (5) regulate all diversions from the lakes for navigation; (6) prescribe the manner in which Ontario and New York may proceed with the development of power in the International Rapids when that becomes necessary; (7) set up a joint commission to determine what navigation facilities must be built in conjunction with power development; (8) allocate the cost of these facilities and of such future facilities as will be required, if and when the seaway is built; and (9) set up the machinery to control the movement of power across the border.

A PROGRAM for development of power in the St. Lawrence and the start of the seaway is not one to be rushed into as a war measure, because at best the power could not be made available for four or five years. Nevertheless, the shortcomings of the present treaty and the fact that the St. Lawrence cannot be harnessed quickly call for an early start on revision of the treaty. Revision should not be tied to the controversial questions of the seaway and public power development in New York. It should be undertaken without commitments as to when construction of either project should start. After arrangements covering the manner in which each is to be carried out and financed have been perfected and made part of the treaty, the question of when either is to start can be made the subject of separate negotiations. Each can then be considered on its own merits, which is not possible now when so many other questions are involved.

ENGINEERING NEWS-RECORD
Copyright 1941, by McGraw-Hill Publishing Company, Inc.
WALDO G. BOWMAN, *Editor*. J. I. BALLARD, *Managing Editor*. *New York*: V. T. BOUGHTON, E. J. CLEARY, A. N. CARTER, H. W. HUNT. *Chicago*: W. W. DeBERARD, H. W. RICHARDSON. *Washington*: PAUL WOOTON, R. B. COLBORN. *San Francisco*: N. A. BOWERS. *Consulting Editor*, F. E. SCHMITT.
EDITORIAL OFFICES: 330 WEST FORTY-SECOND STREET, NEW YORK, N. Y.



One of the four shields in operation on the Chicago subway.

Shield Tunneling on Chicago Subways

***Contents in Brief**—Four shields under compressed air drove a total of 20,062 ft. of single-track tunnels for 3.1 miles of the new Chicago subway system through the downtown Loop district at an average advance of 25 ft. daily. Progress was handicapped by the necessity of removing the concrete-lined Chicago freight tunnel ahead of the shields and backfilling with sand. Primary lining was fabricated structural steel segments. Mining out of areas for stations was an interesting feature of a highly successful job.*

COMPRESSED-AIR SHIELD TUNNELING for the twin tubes of Chicago's initial subway system through the downtown Loop business section has been successfully completed, with each of the four shields used advancing an average of 25 ft. per day. Two of the shields, progressing northward under State St. from 11th St. to Wacker Drive, ran 6,145 ft. each. The other two, starting eastward under Lake St. from La Salle St. and turning south into Dearborn St. to Van Buren St., each advanced 3,886 ft. The four shields, identical in design, were 24 ft. 10½ in. in diameter, and in general ran with top of hood about 25 ft. below street surface. A serious handicap to shield operation was the presence of the concrete-lined narrow-gage Chicago freight tunnels, which had to be removed and backfilled with sand ahead of the shields. For the most part the freight tunnel section covered the lower quadrant cutting edge of the shields. Yet, despite the freight tunnels, the superimposed load of buildings and street traffic, the maze of utilities lying between top of subway and street surface, and deep subbasements, the shields traversed a total of 20,062 ft. through soft blue clay without a serious mishap or loss of ground, or damage to utilities or buildings, and with a minimum of disturbance to street traffic.

The initial stage of the Chicago subway system, involving 8.75 route miles of tunnels, is being built by the city Department of Subways and Superhighways with a PWA grant. In 1939 bids were called for tunnels on the State St. route through the Loop on a 330-day schedule, which would have required four shields, two starting at each end. The resulting bids were considered too high, so the job was re-advertised on a 450-day basis, requiring only one pair of shields. In September, 1939, the Dearborn St. route was let, both contracts going to one contractor, the Healy Subway Construction Corp. Thus both jobs were conducted in the same manner, and operations described herein are typical for both sections.

The State St. shields started driving

in January and March, 1940; the shields for Dearborn St. started in March and April, 1940. On Oct. 19, the latter shields reached their contract limits, and on Jan. 10, 1941, the State St. shields reached the end of their run, 280 ft. south of the river. A hand-mined tunnel connection will be made at this point between the shield tunnels and tubes sunk in the river under a previous contract. All of the remaining 4.9 miles of tunnel route on the system, built by hand-mining methods under compressed air (*ENR*, Aug. 1, 1939, p. 159) was finished last October. Anticipating an additional PWA grant, which was announced in December, the Dearborn St. shields were left in place beyond the contract limits and taken over by the city pending a contract for an extension of this route south to Congress St. and thence west to the river, where a turning loop and stub ends for a future extension westward will be built. The State St. shields are being dismantled.

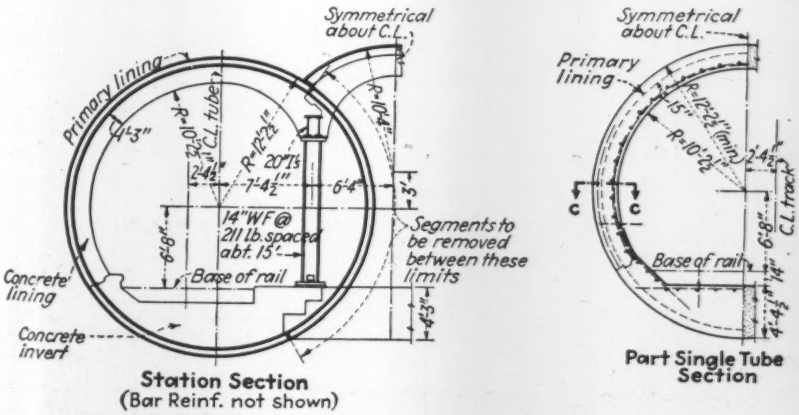
Ring drilling for demolition (left) of the Chicago freight tunnel ahead of the shield. Parts of the concrete lining were 3 ft. thick. Right, mining out one of the six shield pockets with a power knife.

Design of shield tunnels

Subway tunneling started on the hand-mined sections, and as the work progressed city and federal authorities became convinced this method would be unsuitable for the Loop area tunnels. Shield tunneling was adopted, therefore, for the following major reasons:

1. Uncertainty of holding air pressure in an area containing numerous utilities, as well as deep sub-basements that extend 20 ft. below the surface.
2. High water content, as much as 58 percent, of the blue clay in the Loop area, which lowers the safe bearing value of the soil for carrying required loads.
3. Probable inability of the lighter steel lining used in hand mining to withstand external pressures in case of loss of air.
4. Ground pressures resulting from high loads of buildings on spread footings would require lining segments too heavy to handle by hand.
5. Hand mining would be slower, because of need for elaborate breasting to eliminate soil movement at the face. Furthermore, the hazard of losing a heading with possible high loss of life and property would always be present.

Outside of station areas the shield-driven tunnels are separate single-track twin tubes 24 ft. 5 in. in diameter with a minimum total lining thickness, primary and secondary, of 2 ft. Base of rail is 6 ft. 8 in. below center line and 14 in. above the concrete invert slab. The tubes were driven parallel 27 ft. 5 in. apart on center lines, or only 3 ft. apart outside to outside. In stations (all of center platform design) the same spacing was maintained, but the design called for breaking out of the ground between tubes under a hand-mined arch, and replacing the tube sidewalls on the platform side with columns and girders. The columns are 14-in. 211-lb. sections, supporting a pair of 20-in. girders continuous through the station area. Columns rest on the invert slab.



Design of the shield tunnel sections. Station sections were driven as two separate tubes, then the wall on the platform side was broken out, after the arch was supported by columns and girders, and the section between tubes was built by hand-mining methods.

Shields and steel lining

The shields were exceptionally well designed and built, and handled nicely, even to operating around a curve of 275-ft. radius. They were 25 ft. 3½ in. in outside diameter, formed of one horizontal and two vertical girders dividing the interior into six pockets. The overall length at the hood was 19½ ft., at the bottom 15½ ft., including a tail 6 ft. 11 in. long. Skinplate throughout totaled 2½ in. thick, the various plates being riveted together. Each pocket was equipped with a sliding or breasting platform handled by two hydraulic jacks. The 24 shoving jacks were 10-in. hydraulic, rated at 200 tons each under a 5,000-lb. pressure. Actual pressures used, however, were considerably less than the maximum

capacity, and rarely were all the jacks required for a shove. The front end of each pocket was fitted with grooves to take steel stoplogs to reduce the area of the opening when desired. Each shield weighed 225 tons, and included 72,196 shop rivets and bolts weighing 58,748 lb., and 24,432 field rivets and bolts weighing 28,936 lb.

The primary lining segments erected within the shield were an unusual design of all-welded fabricated steel plate reinforced by T-sections. The segments were 33 in. wide, and 12¾ in. deep; six full units and a key made up into a 33-in. ring of lining. In station areas alternate rings included two half-lengths of standard segments so there was a continuous longitudinal joint line in the upper and lower inside quadrants to permit removal of two full plates and the key for the platform opening.

Five ⅜-in. plates formed the back, sides and ends of the segments. An inside flange was formed by two 1x4¾-in. plates welded to the side plates with the long dimension outstanding. Full plates had 11 longitudinal (with tunnel axis) 4x4½-in. T-sections, the bottom of the T-stem being welded to the backplate. The shield erector arm gripped any one of the T sections for lifting the segment into place in the ring. All bolts were ⅞x2½ in. Each full segment was machine drilled for 72 bolts.

Erecting the fabricated steel lining.

Underlying every street in the Loop district is the city-owned privately-operated Chicago freight tunnel system, a narrow-gage railroad line in single-track 8½-ft. concrete-lined tunnels. At street intersections there are four-way connections, and numerous laterals lead off the main route to serve stores and office buildings. In general, track level of the freight tunnel is about that of the new subways, so the freight tubes had to be removed ahead of shield driving. The freight tunnels lie in the middle of the street, just right to catch the lower quadrant of each shield. While the freight tunnel system will be put out of service on Dearborn and State streets, and on all cross-streets between the two, it will be able to operate from the Clark and Wabash St. routes.

The freight tunnels were both a headache and an advantage to the subway contractor. It was a ticklish job to demolish the old concrete lining and backfill the tunnels with sand without losing ground, but the system offered an easy method to dispose of tunnel muck, both from the freight tubes and the subway.

Demolition of the freight tunnel proceeded about 100 ft. ahead of the forward shield. The procedure was to put a short section, a block or so long, under 12 to 15 lb. of compressed air. Locks were installed in the north-south tunnel, usually just short of a street intersection, and laterals and crossings in the compressed air section were closed by bulkheads. The concrete lining was ring drilled from a column mounted on a small truck, and shot out in sections 5 ft. long. The broken concrete was immediately removed and the demolished section backfilled with damp sand packed tight. After some trouble at the street intersections it was found best to shore the top and bottom of the wide intersection areas with lagging held by posts to prevent loss of ground. As the shield approached the posted areas it was necessary to mine out ahead and remove the timbers through the shield pockets.

An all-diesel compressor plant, located on the lower level of Wacker Drive at Dearborn St., furnished the air for demolition of both tunnels.

Steel bents supported station girders and tunnel arch while platform section (left) between tubes was built. Bents in foreground are being dismantled for moving ahead to new working point.

Plant layout

At each job the plant installation included electric-driven compressors having a low-air capacity of 6,000 cu. ft. per min. and a high-air capacity of 3,500 ft. Electric power was supplied from two independent sources, and diesel compressors were available for emergency service. Air

pressure in the tunnels varied from 11 to 15 lb. per sq. in. Standard lock equipment at each bulkhead was one manlock and one material lock. On State St. the locks were located first at 11th St., then moved ahead three times to Van Buren St., Adams St. and finally to Lake St., where they will serve the hand-mined connection for the river crossing. One installation of locks at La Salle and Lake Sts. served the entire Dearborn St. job. Hydraulic equipment at each job consisted of two hydraulic pumps and one accumulator.

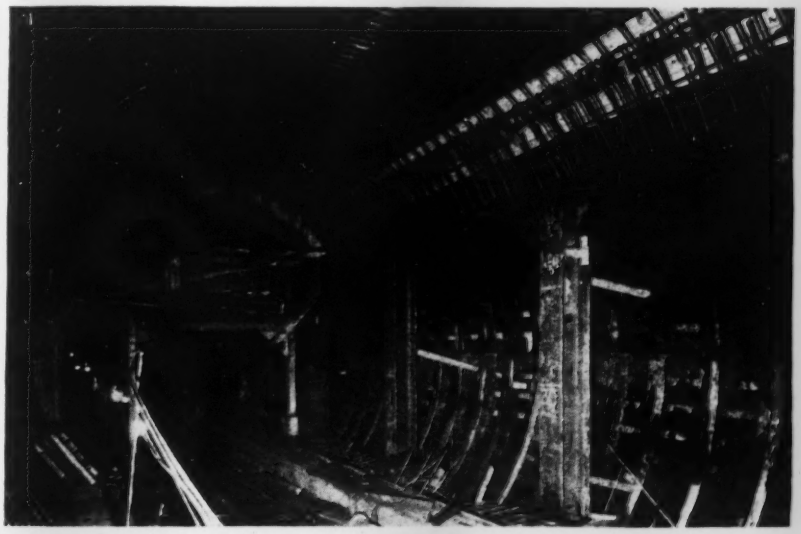
At State St. the shields were erected in a permanent open cut section that will be used for the subway connection to the elevated line. The shaft was sunk on adjacent private property for handling of materials into the tunnels. On the Dearborn St. job advantage was taken of an abandoned rectangular street car tunnel running under the river in La Salle St., whose intersection with the subway was about grade. The Dearborn St. shields were erected in this tunnel, and the east wall was lined, drilled and shot out to permit start of the shields. The subway section was built between tail of shields and the west tunnel wall to take the starting thrust of the shields. A hand-mined section was built later to connect the shield tunnels with a previously-built subway section to the west. The Dearborn St. compressor and hydraulic plant was located over the south ramp of the street car tunnel at street level; the ramp was utilized for carpenter and electrical shops and for the air receivers.

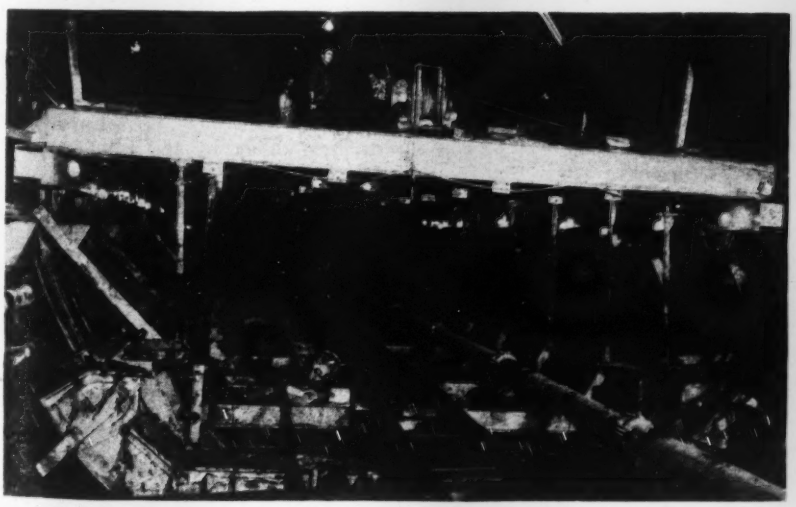
The under-river and north ramp sections of the street car tunnel were used for iron and other material storage. A material lock connected the subway with this underground area. Material trucks entered the tunnel through the north ramp.

Shield operation

The shields operated on a modified form of blind shoving, with the six pockets bulkheaded to reduce the openings to a range of 5 to 20 percent of the total face area. However, the amount of clay removed was as near 100 percent of that displaced as was possible to estimate. To prevent loss of ground, to keep the intake of clay into the shield under control and to avoid settlement of overhead structures, the shield pocket openings were adjusted, according to the stiffness of clay encountered, to build up a ground pressure ahead of the shield during the shove sufficient to raise the street level 2 in. This pressure caused some damage to light sidewalk vault floors that often were only a few feet above top of shield and to some basements, but such damage was minimized by loading of the floors, and even the sidewalks in some cases, with sand bags. No serious damage was done to major parts of structures or to utilities. Deep utility vaults in the street were reinforced and loaded.

During shoves, level parties above ground took frequent readings to determine any surface disturbance. Telephone and signal lines connected these parties with the headings, and in case of undue surface disturbance or raising of the street more than 0.22 ft. a pushbutton on the signal line set off a "howler" at the heading to warn the shield crews. Other survey parties kept a constant check on possible movements of buildings, structures





Station section ready for arch concrete. Columns and girders have been placed and wood form built for haunch of center section arch (right). Segments of primary lining beyond columns will be removed for excavation of platform area.

Invert forms rode on rails fastened to the primary lining. Note track carried through the form. Concrete discharge pipe leading to arch form beyond can be seen at right.

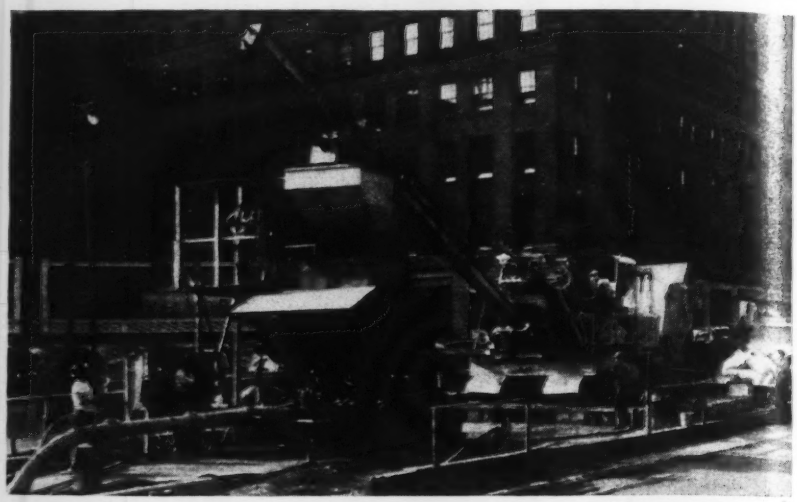
and utilities. Additional survey crews checked lines on the surface and at frequent intervals transferred these lines into the tubes.

A continuous and comprehensive record of settlements and bulges in the street surface, and all disturbances to buildings and structures was kept on special forms. Engineering data were supplemented by photographs.

During the shove the clay was forced into the shield through the pocket openings, where it was cut into slabs by power knives and handled by hand into waiting cars. Where the freight tunnel sand backfill was encountered, air spades were required to excavate the hard-packed material.

The shields operated with remarkable ease. For hours at a time it was possible to hold them exactly on line and grade, and the maximum deviation, well below specified tolerance, was only 1 in. In general, one shield was kept about 300 ft. ahead of its companion.

Each tunnel carried a double track leading right up to the shield, resting on a wide floor of cross-timbers and longitudinal planking. Just behind the shield was a double crossover in the form of a California switch that rode on top of the rails, permitting empty cars to be switched from one track to either track at the shield and loads to be pushed back to storage on the other track. Muck was loaded into cars furnished by the freight tunnel operators, and was hauled away by them to a shaft at Kinzie St. where the spoil was dumped into barges for disposal in Lake Michigan. The contractor cut through between tubes at each street intersection to permit transfer of material and muck cars from one subway tunnel to the other, and installed air locks in each of the crosstown freight tunnels for disposal of muck.



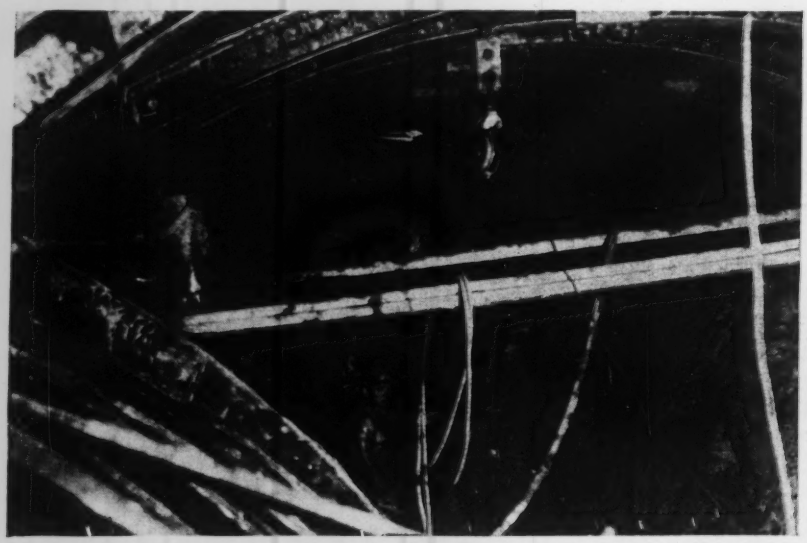
One of several concrete plants at the surface. Concrete was mixed in dual-drum pavers and pumped through pipes leading to the forms in the tunnels below.

The lining segments were jerked off from flat cars by an air hoist line and picked up and placed by the erector arm in fast time. After some practice the crews could set a ring of iron in 20 to 25 min. Experience showed that loose bolting, along with some drifting, was more advisable than tight bolting during erection of a ring. When completed the ring was bolted tight.

Specifications called for combination crossties and struts to be installed at springline for 50 ft. behind the shield, and also in the opposite tunnel in the vicinity of the second shield. S. A. Healy, head of the contracting firm, devised a clever form of tie as one of many contributions he made to expedite the work. The tie consisted of a pair of 8-in. channels formed into a box by coverplates. One end was fitted with a clamp that gripped the steel lining, the other carried a 3-in. screw jack between end of tie and clamp. The tie could be easily installed and removed, and instantly varied in length to correct any change of shape of the lining. These ties were installed in alternate rings of lining.

The subway engineers took measurements for weeks to determine any deflection in the lining as the load of the ground came upon it. Some deflection was noted at once, but as the soil became stabilized a a gradual return to true diameter was observed.

Riding on the tie struts and dragged along by the shield was a jumbo carrying equipment for shooting pea gravel and grout into the tail void. The gravel was shot under air pressure of 30 to 35 lb., during the shove, through 2-in. holes tapped in the segments. A light shot of 1:1 grout followed after the shove was completed to solidify the gravel.



Mining out platform area between tubes under protection of arch ribs.

Concrete lining

All concrete was mixed on the surface in dual-drum pavers, transferred to double-action concrete pumps by

the paver boom bucket, and pumped through pipes into the tunnel directly to the forms. Discharge pipes from surface to tunnel were spaced from 600 to 1,000 ft. apart; one pipe served both tubes. The mixing plant was moved ahead from one pipe location to another as concreting progressed. Discharge pipes were set by digging a pit from street level to below utility line to make sure all utilities were in the clear, then a pipe was jacked up from inside the tunnel through a hole burned in the lining to intersect the pit.

Paving of the invert concrete followed about 500 ft. behind the shield. Traveling invert forms, 75 ft. long on Dearborn for six pours a week, and 105 ft. on State St. for five pours per week, rode on brackets bolted to the primary lining. The form traveler also supported a single muck track over the pour area.

Placing of arch and sidewall concrete followed 250 ft. behind the invert pour, though a section of invert and arch were usually poured together. The concrete plant was kept ahead of the arch forms to eliminate two 90-deg. bends in the discharge pipeline that otherwise would have been necessary. The traveling steel arch forms were the same length as their respective invert forms.

In the station areas the columns and girders were erected before the arch forms were set, and, of course, the wall on the platform side was left unlined. A longitudinal wood form was required on the platform side of the girders to form the haunch of the platform area arch.

Center section mining

The procedure developed for mining and building the center platform section between the tubes and without the protection of the shields, is regarded by the contractor as the key to a successful job. One of the illustrations indicates the columns rested temporarily on a weak overhang of the tube invert. Until the invert of the platform section was poured to complete a firm foundation for the columns, the columns were not capable of supporting the full load of the tube arch and the center arch combined.

To take the load off the columns during the building of the center section, the contractor devised a series of steel bents consisting of 18-in. transverse beams supported by 10-in. H-section posts which were equipped with special 75-ton screw jacks. These posts rested on the full thickness section of the tube invert. One end of the crossbeams bore against the arch concrete; the other end picked up the bottom of the girders. A total of 45 bents to cover 225 ft. of tunnel was supplied for each tube. A traveling gantry was used for erecting, dismantling and moving the bents.

With the girder load carried by the bents, the primary lining on the platform side of the tubes was broken out with air hoists, and the segments were moved ahead for immediate reuse in the shields. Excavation of the ground between tubes was by hand-mining methods. The procedure was to carry an arched-roof top heading ahead of general excavation. This top heading was excavated to a true arch, and as fast as the heading progressed arch steel ribs, in two sections, were placed transversely across the heading as ground support. The outer end of each rib segment carried a plate that rested on the outside of the primary lining; at the inner end was a plate to form a bolted butt joint at the crown. Steel liner plates of the flattened-edge type were slipped over the outside flanges of the ribs to complete the ground support system. This scheme was ideal, for no bolting or fastening of the ribs to the primary lining was necessary, and no clips or lugs on the lining segments were required. Where the tubes had spread apart slightly it was a simple matter to block out to the ribs.

Excavation of the center section was by power knives, and considerable manhandling of the muck was necessary to load it into cars within the tubes. As soon as a short section of invert was ready the concrete was poured, thus completing the foundation and permitting removal of the steel bents. The center arch was poured in a simple traveling steel form supported from the invert.

On all concrete work rigid inspection of materials and close supervision of placing operations produced the dense, practically watertight concrete desired by the engineers. Test cores were taken frequently, and the laboratory record of 400 cylinders broken at 28 days shows an average strength of 3,785 lb. per sq. in. for concrete containing 5½ bags of cement per cu. yd. mixed with 6½ gal. water per bag.

There was a lot of special work required, such as building junction boxes, pump and splicing chambers, vent openings and a complete drainage system. Openings were left in the center arch for stairways and escalators. However, all station platforms, finish, stairways, mezzanines and outside stairways are being built under separate contracts.

Two pedestrian transfer tunnels, one under Jackson Blvd. and the other under Washington St. between the two routes, were built by the subway contractor.

Direction

The subways are being built by the Chicago Department of Subways and Superhighways, Philip Harrington, commissioner. Ralph H. Burke is chief subway engineer, P. F. Girard is in charge of design, and construction was in charge of A. M. Crain, succeeded last fall by V. E. Gunlock. J. Walter Grimm is resident engineer at State St.; R. A. Bonnell at Dearborn St. Chas. E. DeLeuw is consulting engineer.

For the Healy Subway Construction Corp. S. A. Healy is president and Louis Salmon is chief engineer. Harvey Kruse is superintendent on the Dearborn job; Wm. Ragland on State St.

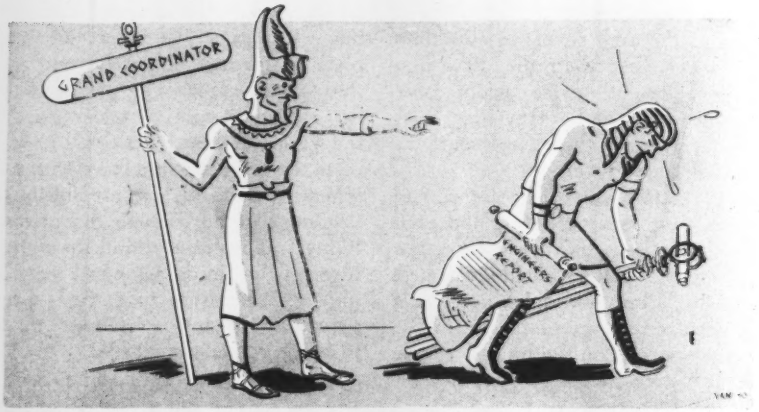
Well-Water Discharge to Sewer Systems

A survey of private wells, to determine the number of such wells which contribute used water to the sewerage system, was one of the activities of the Board of Public Works and Sanitation, at Indianapolis, Ind., as recorded in the 1939 report. This information is of value in two ways: (1) it gives the quantity of water which, added to that produced by the water company, should equal the sewage flow; if that flow is larger it indicates the amount of infiltration to the sewer system; (2) the quantity of water from the wells in any one plant is an indication of the amount of waste water leaving that plant. The survey showed 205 wells, of which 60 are for air-conditioning service only. The maximum total flow was 31,130,330 gpd., while the amount used for air conditioning was 3,837,410 gpd. Considerably more than this latter amount is used for air-conditioning, including city water, and discharged to sewers.

"...faced with a limited emergency..."

The Pharaoh and His Planning Board

***Contents in Brief**—A recently discovered manuscript reveals that organized planning existed 3,300 years ago, in the reign of a Pharaoh of the Dew'er Dynasty. Faced with a limited emergency when the Nile went into flood, the Pharaoh called for his planning board. What they did is revealed in the following fable. And like all fables, this one has a moral.*



"Go! You have the narrow viewpoint of an action agency."

R. Dent Planeur

PLANNING has been an integral part of man's cultural heritage since the earliest forms of social organization to which the word "civilization" can be applied. This contention is borne out by recently discovered evidence which indicates that organized planning existed far earlier in history than had heretofore been suspected. This new evidence is a papyrus manuscript, evidently of the time of the Pharaoh Nwab'i Ch'ow, founder of the Dew'er Dynasty which ruled Egypt from about the 13th century B. C.

The hieroglyphics are exquisitely fashioned, the language refined, and the style delicate, bespeaking a cultured gentleman of the *twad'l* (or intellectual) class. The papyrus is watermarked "Egyptian Government —for official use only" and the characters were apparently inscribed with a pa'ka feather ("The Lifetime Quill") which was at that time extremely costly, and was available (in the government service) only to officials of the class of *sn'ob* or higher. There is considerable authority, therefore, for ascribing authenticity to this manuscript, which read as follows:

In the third year of the reign of Nwab'i Ch'ow it came to pass that the Nile was angered and began to rise above his banks. Upstream many houses were carried away by the dark waters, but at Cairo the city was protected by levees and the palace of the Pharaoh was surrounded by a great dike. One ill day, however, a palace guard rushed breathless into the palace and threw himself before the Pharaoh saying that the dike around the palace was weakening, and that it would not last many more days. So the Pharaoh had his head chopped off for being a harbinger of bad tidings, and called his planning board.

"Gentlemen," said the Pharaoh, "we are faced with a limited emergency. The dike outside the palace is in some danger of collapse, and I would like to have you make plans for strengthening it. Don't give me any of your landscaping on top of the dike, and don't think you can keep out the Nile by zoning the palace grounds as dry land. Get to work on fundamentals. If you succeed in producing a waterproof dike, I will reward you well—I will even make you a permanent agency; but if you

fail, I will tie you to a tree in the palace yard and have the exquisite pleasure of watching the water rise above your heads." And with these words he turned back to his lyre and his lotos brandy and a dark-complected lady from up near the Second Cataract.

Seven is a sacred number

So the planning board hired some offices with a big round conference table and began to think. "First," they cried, "we must have a Plan for Planning." "Yes," cried others, "we must provide for the necessary integration at all levels of government." So they got a map of Egypt and divided it into seven regions (seven being a sacred number) and appointed many consultants and draftsmen for each regional office. Then they appointed several coordinators, one for each subject, such as Land, or Water, or Public Works, and finally they appointed a Grand Coordinator to coordinate the work of all the others.

When this was done, someone cried "Our next need is for Basic Data!" "Yes!" chorused the Board. "We will set up a committee on Basic Data!" So a Committee on Planning Data was set up. Then the Committee set up several Subcommittees: Subcommittees on Deficiencies in Hydrologic Data, on the Agricultural Aspects of Flood Control, on the Social Implications of Low Dike Construction, the Institutional Barriers to Effective Flood Control, Fiscal and Monetary Problems, and Engineering.

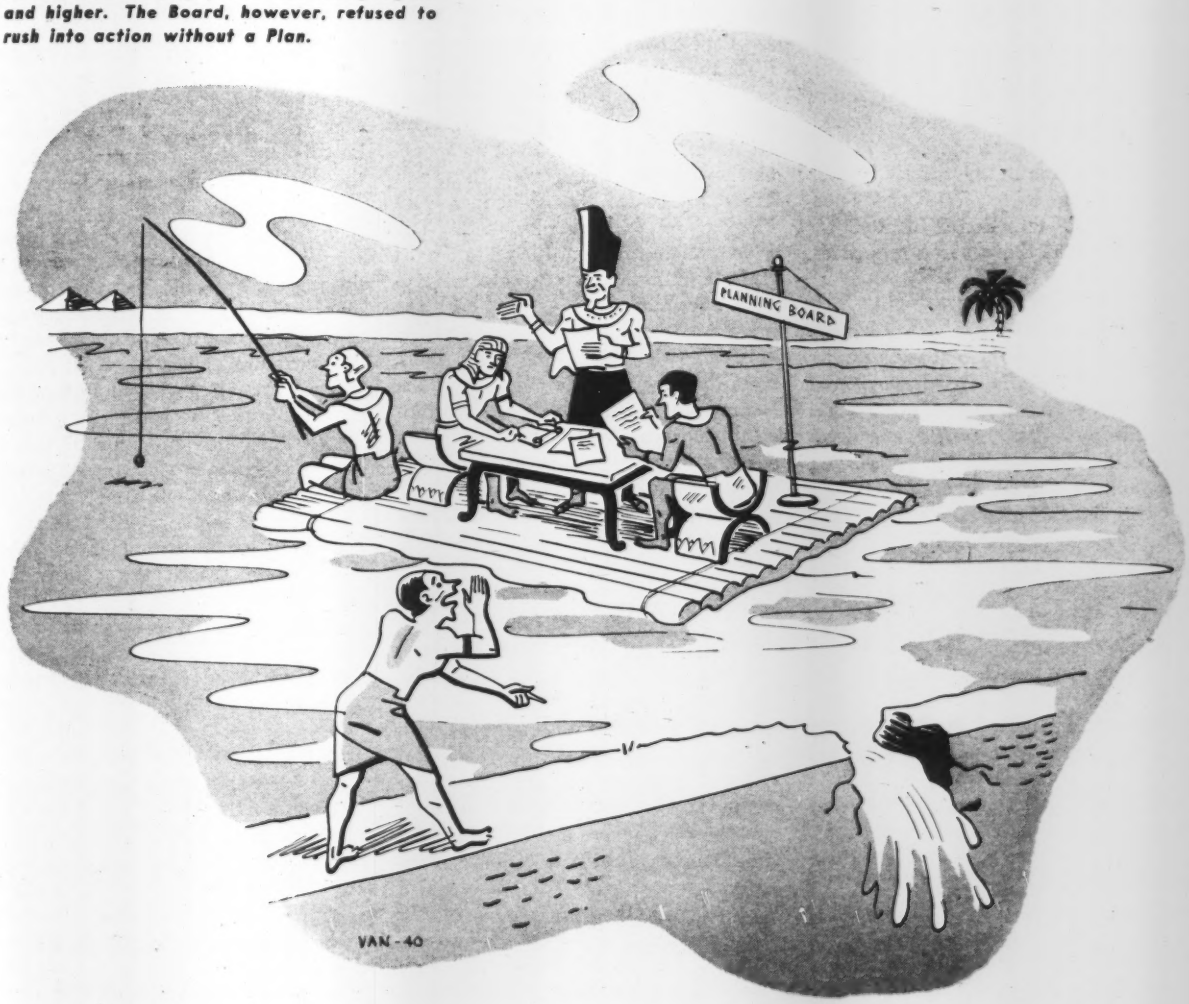
One by one these subcommittees reported. First the engineering group brought in a report that the riprap on the dike had washed away, and that was why it was weakening, and that this defect could be remedied by the application of a few tons of clayey earth and riprap. This report was disregarded, however, because the engineers who made it had the narrow, biased viewpoint of an action agency and the report itself could hardly be considered as comprehensive in scope.

Reconciled by The Index

The Committee on Hydrologic Data had sent out its men to query the oldest inhabitants as to the history of floods, asking such questions as "What was the highest flood crest you remember?" "What year?" etc. Of course, these old gaffers had unreliable memories, so that much of the information did not click, but it was handed to the statisticians, who reconciled the conflicting accounts by establishing a standard deviation. This, in turn, was multiplied by the square root of *pi*, and was called simply The Index.

The Committee on Social Impli-

All this time the angry Nile was rising higher and higher. The Board, however, refused to rush into action without a Plan.



cations reported that the dike did not provide adequate play space for the underprivileged children of Cairo; that four out of five "dike families" spent less than 20 sesterces per capita per annum for leafy, green vegetables; and that the dike formed an arbitrary social barrier between the marsh-dwellers and the river-boat people, intensifying and sharpening class distinctions. The subcommittee recommended a sweeping investigation of relief administration and advocated the exportation of aliens living on public funds.

All this time the angry Nile was rising higher and higher. The police teletypes were flashing the latest developments: "Flood crest now 33 feet at Cairo signed O'Malley." "Water at Memphis over levees stop city water supply threatened many families stranded stop inform red cross signed Brown." The Pharaoh sent an inter-office memorandum to the Planning Board calling their attention to the fact that the emergency was less and less limited all the time, and reminding them of the dire punishment attendant upon their failure. The Board, however, refused to rush into action unprepared. "If a thing is worth doing" its chairman wrote in the Egyptian Planning Quarterly, "it is worth doing well." With that pronouncement, the Board waited for the reports of the other Committees.

Reports of committees

The Fiscal and Monetary group said that one reason for the weakness of the dike was that it was burdened with an excessive capitalization and struggling to carry too large a debt. The dike was also, it turned out, in the jurisdiction of several layers of government, all of which would have had power to tax it if it had not been government property and therefore tax free. The subcommittee recommended a drastic overhauling of "our antiquated tax system, the elimination of obsolete units of government, the immediate refunding of the Cairo Dike Commission's bonded obligations, and the balancing of the national budget next year."

The Committee on Agriculture and Institutional Barriers also reported, but their reports were confidential, so that little is known of their findings and recommendations. It was rumored about Cairo, however, that the agriculture group contemplated some daring experiments with a new plant called the soy bean.

During all this the Nile's waters were rising, and by the time the Board had received all its Basic Data, the water was only a few inches below the top of the big dike around the palace. The Pharaoh moved his lyre and his lotos brandy to the second floor, and sent his lady-friend to her aunt's house in a skiff. The Planning Board sent him an Interim Progress Report stressing the need for a comprehensive approach to the problem and coordinated effort at all levels of government. The Pharaoh sent back the report with the notation that there were only two levels of government in Egypt, both very low, and that if they got below the water level the Planning Board would go down with them.

The next step of the Planning Board was to prepare a Master Plan. The Master Plan provided for the comprehensive and integrated development of the Nile all the way from Lake Tsana to its delta—it was a social and economic as well as a physical program, designed to promote the wise conservation and utilization of all Egypt's resources, human and natural. Planning circles were inspired by the grandeur of its scope, and by the sweeping way in which broad principles and objectives were blocked out with a bold hand. The Plan called for a unified system of locks and dams to promote navigation, irrigation systems for the marshlands along the banks, and for a scenic highway along each bank from the source to the mouth. At the last minute one of the narrow-minded Engineers insisted that the plan contain some provision for strengthening the dike at Cairo, but he was regarded as an old betty, and the Board told him that this was merely a detail which could be filled in later.

From the ground up

When the Master Plan was completed, the Board said "Now we must achieve decentralization of planning. This plan must not be imposed from above: it must proceed from the ground up." So a great campaign was started to have the Plan proceed from the ground up. The expensive regional consultants went around to dinner meetings and other stuffy affairs, telling people that Good Planning Is Good Business. Boy Scouts were sent from door to door with petitions, and the Egyptian Legion paraded through the streets drumming up local demand for "The Master Plan."

Meanwhile the Plan was being worked over by the Planning Board's Division of Deletion, which carefully emasculated all proposals that might rouse the antagonism of the Upstream Business Men's Association or the Nile Valley Real Estate Conference. The Plan was then printed up in tentative form and circulated for "technical review and comment" to leading scholars and public officials of the country.

The check-up

All this routine was very boring to the Board, of course, since its outcome could not possibly affect the Board's decisions, so they decided to take a vacation trip on a steamer up the Nile. This was known as "checking up on the regional offices."

Everybody said they were crazy to go out on a boat when the Nile was in flood, and the Pharaoh sent them another memorandum reminding them that a little water was already slopping over the dike. But they said "There is no use in devising hasty plans and attempting to evade the operation of certain Immutable Planning Laws. Half a plan is worse than none. We must not let a profusion of trees obscure our vision of the woods." So they left the regional officers in charge of integrating anything that came up, and then boarded the steamer.

The day after they left the dike gave way, and the water poured over the city of Cairo and into the palace. Everything was washed away including the Master Plan, and everybody was drowned including the Pharaoh—everybody except the planners. When they came back they ransacked the flotsam until they found some pencils, and they sat down to draft a broader, better-coordinated Master Plan for a broader, better-coordinated Society.

Apologia

Planning is a process as old as the hills, although present-day writers on the subject would ascribe to it the glamor of novelty. Therefore, should any of the experiences of the Pharaoh bear a resemblance to current planning problems and procedures, this coincidence merely proves that history will repeat itself.

Aerodynamic Action on Wires and Bridges

Blake D. Mills, Jr.

Department of Mechanical Engineering
Massachusetts Institute of Technology, Cambridge

***Contents in Brief**—The movements of the Tacoma Narrows Bridge preceding its collapse may have involved one or more of three aerodynamic phenomena: galloping, wind eddy vibration, and flutter. Long studied in relation to wires, these actions can be demonstrated on models.*

COLLAPSE of the Tacoma Narrows suspension bridge made evident the vital part which unforeseen aerodynamic effects can play in a structure designed primarily for static loads. It is the purpose of this article to illustrate the manner in which such effects may be introduced.

Opened to traffic in July, 1940, the Narrows Bridge often exhibited a marked "bouncing" action, and ultimately collapsed on Nov. 7, 1940, dropping the deck and stiffening girders of the center span into the water. The "bouncing" action, a vertical vibration of the deck and cables of all three spans, had different amplitudes, frequencies, and modes of vibration on different days. When observed by the writer in August it had four nodes or points of zero vibration intermediate of the ends (Fig. 1), and the vertical motion was approximately 4 ft., at a frequency of 20 cycles per minute.

Galloping—One of the possibilities is that known as "galloping", which has been discussed in detail in engineering literature[1, 2, 3, 4, 8], especially with regard to transmission lines. This galloping does not ordinarily occur on a round wire, but has been observed on wires coated with sleet to a vertically elongated section. Galloping of wire spans has occurred with vertical motions of 20 ft. and frequencies of one cycle per second or slower when winds exceeded 20 mph.[3]

The conditions of galloping may be simulated on a model such as that shown in Fig. 2, wherein a section of a beam, elastically supported, is placed in the horizontal airstream of an electric fan[1, 3]. The wooden beam shown readily built up a vertical bounce of more than 1 in., at a frequency that did not vary appreciably with wind velocity and corresponded to the natural frequency of the spring-supported beam. A similarly supported beam of half-round section proved exceedingly unstable when its flat side faced the wind, but refused to bounce when its convex side was to windward. This phenomenon has often been demonstrated.

Fig. 1. An observed configuration of Tacoma Narrows main span, indicating the four nodes diagrammatically.

To stabilize the test beam of Fig. 2 the holes shown were drilled through the beam web, but they reduced the vibration amplitude by only about 10 percent. A thin cardboard "windbreak" attached to the windward face of the I-beam, as in Fig. 4, completely stabilized the beam; even when given a vertical impulse manually, it quickly came to rest. Attached to the leeward side of the beam, the "windbreak" had very little effect. These effects correspond very nearly to the behavior of the half-round beam mentioned previously.

Vibration by Wind Eddies—The second possibility is vibration induced by wind eddies or Kármán vortices, which also has been observed on transmission wires and has been the frequent cause of fatigue failures[1, 5, 6, 7, 8]. Unlike galloping which has one of the natural frequencies of the structure, this wind-eddy vibration has a frequency principally dependent upon the wind velocity and the size of cross-section of the vibrating member. The amplitude is of course accentuated when the forcing frequency corresponds to a natural frequency of the system.

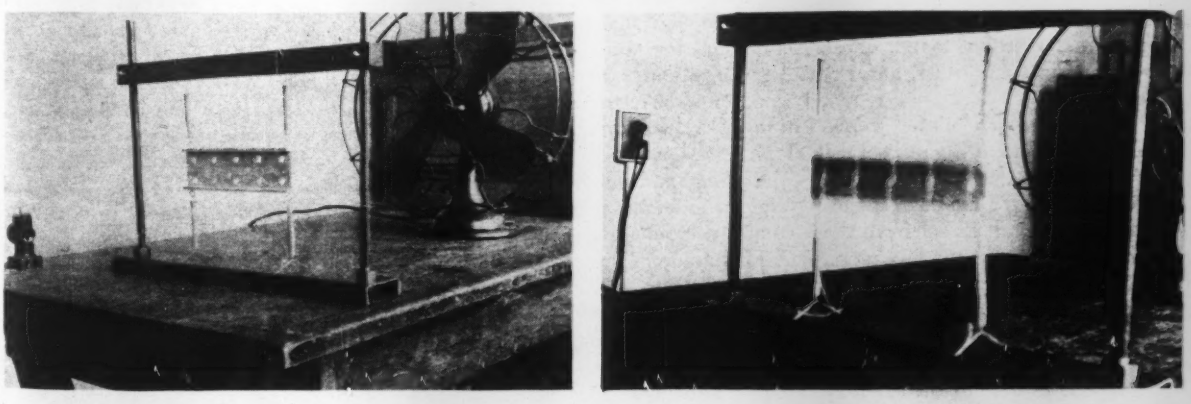


Fig. 2. Spring-supported model I-beam, shown at rest in left view and vibrating in fan blast at the right.

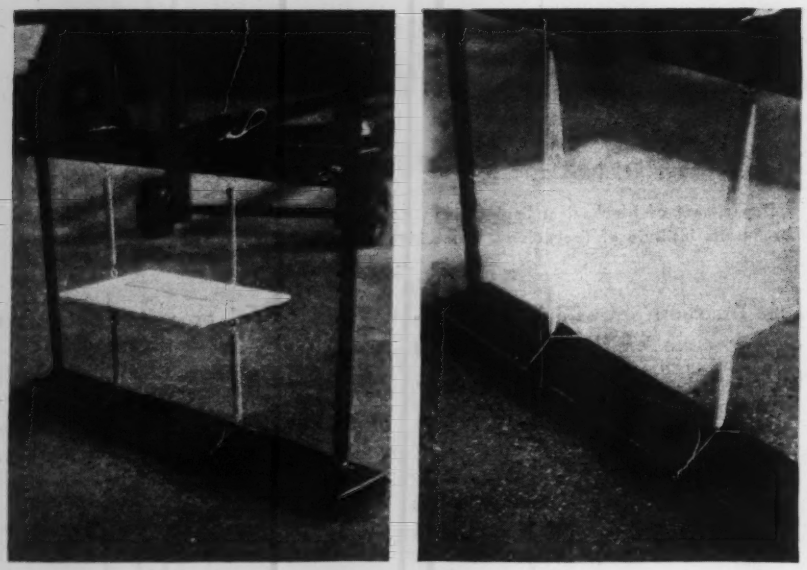


Fig. 3. Horizontal vane at rest and fluttering with a vertical bounce and roll.

When a light cylindrical beam was substituted for the I-beam model no appreciable vibration was produced at the maximum fan speed. However, when the wind velocity was gradually reduced a condition was reached in which the beam bounced continuously, with 2-in. vertical motion.

The following relation was developed many year ago[5] for the vibration of fine wires with transverse wind, but has been found to hold reasonably accurate for larger sections: $f = 0.2\left(\frac{V}{D}\right)$, approximately, where f is the vibration frequency, V the wind velocity, D the diameter of the section, and 0.2 a dimensionless constant. Units may be anything consistent among f, V, and D. More accurate expressions for transmission-line vibration have been developed[7]. For sections other than round the relation holds reasonably well if an "effective" value for D is determined experimentally; this effective D may be approximately equal to the depth of the section in some cases, and not in others.

For the 20-cycle-per-minute vibration of the Tacoma bridge observed by the writer, and using for D the girder depth of 8 ft., the corresponding wind velocity calculated from the equation becomes about 9 mph., which is considerably less than the actual velocity existing at the time of observation. This does not eliminate the possibility of wind-eddy vibration, however, as the effective D may well be considerably greater than the girder depth. As a matter of fact, this type of vibration might account, better than galloping, for the fact that the bridge vibrated at different frequencies on different days.

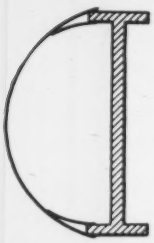


Fig. 4. Cardboard windbreak attached to the windward face stabilized a model I-beam. Even when given a vertical impulse manually, it quickly came to rest.

It might be mentioned that the model girder, Fig. 2, was not appreciably vibrated by wind-eddy effect, because the wind velocity, size of section, and natural frequency did not approach the conditions of the equation for wind-eddy vibration. Any vibration caused by wind-eddies would not be removed by the addition of a "windbreak", as was galloping.

Rolling motion of the bridge—Violent sidewise rolling of the Tacoma bridge deck was noted on Nov. 7. This mode of vibration seems very much akin to the well-known and troublesome "flutter" which occurs in airplane wings under certain conditions and which has been subjected to a great amount of study in that field[1, 9, 10, 11, 12]. Such rolling vibration is ordinarily associated with a simultaneous transverse vibration of the member, where the natural frequencies of rolling and of transverse vibration are of the same order. Photographs taken during failure of the bridge appear to indicate that a rolling vibration was occurring simultaneously with a vertical bounce having nodes only at the center and ends of the span.

In vibrating systems having several possible nodes of vibration, a vibration beginning in one of these nodes may develop into other nodes. Accordingly, either galloping or wind-eddy vibration could very well provide an initial vibration from which rolling or "flutter" might develop. "Flutter" having once begun, high winds could readily amplify it to violent proportions.

When a thin horizontal wooden board was substituted for the I-beam model of Fig. 2, as shown in Fig. 3, a vertical bounce combined with rolling was produced. However, this is not a very close representation of the bridge conditions, and is mentioned only as a matter of general interest.

Observations summarized

Summary—The dynamic properties of a suspension bridge may become extremely important even when the applied loads on the structure appear to be essentially steady in nature. Perfectly steady winds can produce galloping, wind-eddy vibration and flutter. Each of these phenomena has been studied for special cases, but none has been considered to have important bearing on suspension bridge design.

BIBLIOGRAPHY

1. J. P. Den Hartog, Mechanical Vibrations (McGraw-Hill).
2. A. E. Davison, Galloping of Ice-Coated Electrical Conductors, *Electrical News* (Toronto), Nov. 1, 1939.
3. J. P. Den Hartog, Transmission Line Vibrations due to Sleet, *Trans.*, A.I.E.E., Dec. 1932.
4. J. G. Baker, Self-Induced Vibrations, *Journal of Applied Mechanics*, March 1933.
5. R. Ruedy, Vibrations of Power Lines in Steady Wind; the Alternating Forces as Exerted by the Wind, *Canadian Journal of Research*, Sec. A, Oct. 1935.
6. D. B. Fish and F. E. Gregory, Characteristics and Energy Relations of Conductor Vibrations, *Electrical West*, May, 1935.
7. T. Varney, Notes on Vibration of Transmission-Line Conductors, *Trans.* A.I.E.E., 1926.
8. Bibliography on Vibration in Electrical Conductors, Including Allied Researches (1934-36-37-38) A.I.E.E.
9. T. Theodorsen, General Theory of Aerodynamic Instability and Mechanism of Flutter, *Report* 496, N.A.C.A., 1935.
10. P. B. Walker, Mechanical Aspect of Flutter, *Aircraft Engineering*, Feb. 1938.
11. F. Nagel, Static and Dynamic Model Similarity, *Journal of Aeronautical Sciences*, Sept. 1939.
12. Bibliography of Vibration and Flutter of Aircraft Wings and Control Surfaces, compiled with cooperation of A. Klemin; U. S. Works Progress Administration 1937.

Symbols for Soils in Profile

A. W. Johnson
Senior Soils Engineer, Kansas Highway Department, Topeka, Kan.

***Contents in Brief**—For easy reading of soil profiles in field and office, Kansas highway engineers have devised standard symbols based on textural grouping. Problem involved (1) the identifying of soils from test results and (2) the selection of an adequate set of symbols. Easy drafting as well as quick identification result, as proved by several years' actual use.*

THE ADOPTION of the soils survey as an integral part of the preliminary-plans survey in Kansas several years ago made it necessary to draw soil profiles of all projects for use by designers in preparing the plans and for later use by field engineers during construction. Since the field work as well as the drafting of the soil profiles was carried out by field forces, it was necessary to design conventional symbols to represent the different soils between the outlines in which they occurred in the soil section.

A review of the literature on soils in both the agricultural and engineering fields at that time showed that the symbols used to represent soils in profile differed widely, almost every author using a different set of symbols. Only a few symbols were found which were easily legible on standard profile paper and which could be memorized easily and used by both those conducting the soil survey and those using it during design and construction.

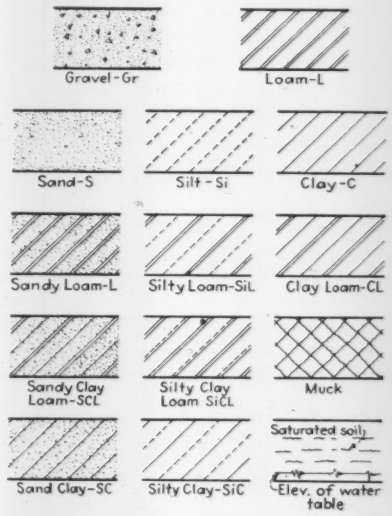


Fig. 1. Standard symbols for showing soils in profile that are easy to draw and identify.

A two-part problem

The problem of showing soils in section was twofold. The first part of the problem was to determine how the soils were to be identified from test results. Considerable thought was given whether to group the soils according to their broad physical characteristics or to group them according to their textural grading. Since all recommendations as to the selection and use of soils are made by the soils department on the basis of the physical properties it was necessary only to identify the various soils by sample number and show their extent by means of their textural grouping. The widely used U. S. Bureau of Chemistry and Soils grouping of textural types based on mechanical analysis was adopted for showing the soils in section.

The second part of the problem was to design a set of symbols which would distinguish the various textural types or groups, i.e., sand, sandy loam, sandy clay loam, etc., from each other in the soil profile.

A study of the various symbols or characters used by architects, engineers of the various branches of engineering and by soil scientists, showed that it would be virtually impossible to work out symbols which were entirely new and had not been used heretofore. It also brought out the fact that some symbols were recognized and remembered more easily than others. Some were difficult or slow to draw, while others were drawn easily and rapidly. Some which appeared desirable were already in use and have been more or less standardized by architects and by geologists,

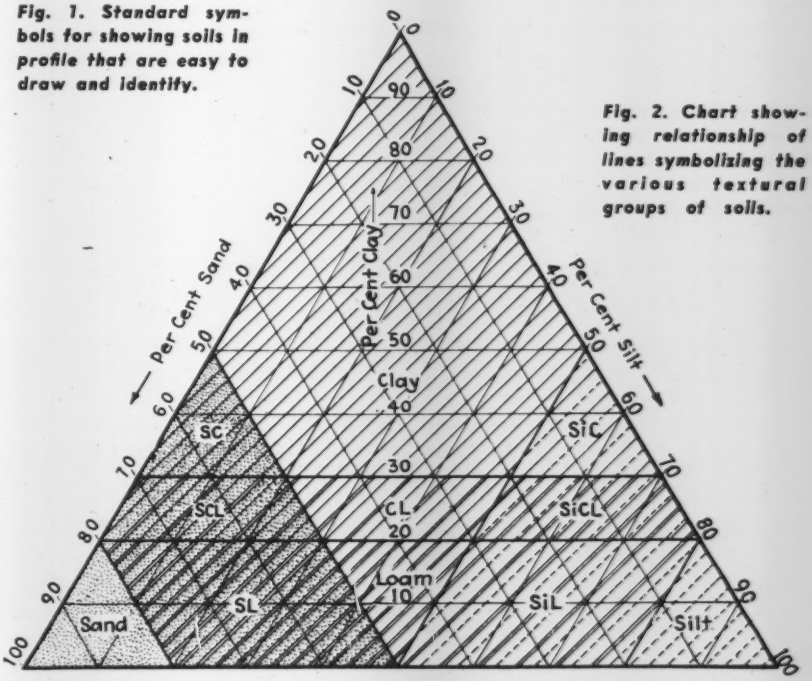


Fig. 2. Chart showing relationship of lines symbolizing the various textural groups of soils.

and, if used, would obviously be confusing.

All ordinary soils consist of mixtures of the various soil fractions. A logical set of symbols, therefore, would naturally consist of individual symbols for the soil fractions which could be combined to form the various soil mixtures or textural combinations. It was found possible to design symbols which not only met these requirements but also to design them so certain lines of each symbol would be common to the various soil mixtures. It was anticipated that this would speed the drafting process when a number of different textural types occur in successive soil horizons.

Familiar sand symbol

A review of literature on the subject showed that nearly all authors used a number of dots to represent sand. The U. S. Bureau of Chemistry and Soils had used continuous lines of different weight in some of their soil survey publications (*Soil Survey of Cherokee County, Kans.*, by Percy O. Wood and R. I. Throckmorton in 1912) to show related textural groups (for example, silty loam and silty clay loam) in profile.

The more or less standard method of showing sand was adopted. The widely used dotted line was used to designate silt. The solid line used by A.S.M.E. for representing cast iron was chosen to represent clay and their symbols for cast steel to represent loam. It was decided to draw all symbols at 45 deg. to improve their legibility on standard profile paper, and to make all lines of identical weight to facilitate drafting. These individual symbols for fractions and for the combining term loam were then combined as shown in Fig. 1 to form the symbols for the various textural soil types.

The resulting symbols are easily memorized for use, are recognized without difficulty and can be drawn with relative ease and rapidity. These facts have been well demonstrated during the several years that they have been in use by the Kansas State Highway Deparment.

An example of the relationship of lines as regards their continuity in drawing profiles which have a number of successive soil horizons, differing in texture, is illustrated in Fig. 2, the widely used chart for showing the limits of various textural soil groups.

Distribution System Records

Contents in Brief—Abstract of a report to the American Water Works Association outlining the methods to be used in recording information on charts, forms and maps.

THAT complete, well-planned and well-kept records of the distribution system of a waterworks utility have important economic and practical advantages in the operation of the utility is logical and obvious, but still is not always realized by utility managements. These advantages apply universally to large and small utilities, in private and in municipal ownership. The above statements present in brief the foundation of a report to the American Water Works Association by its committee on distribution records. The report is accompanied by a review of methods, maps, charts and statistical forms for the simple and effective keeping of such records. The purpose of the report is to provide adequate permanent records of physical assets, and systematic records to assist in effective operation. In fact, it is definitely stated that such a system of records is as necessary as a permanent and detailed accounting of the financial aspect of the utility.

Where rates are based upon the value of the waterworks property, this value (or rate base) is determined usually by an inventory and appraisal of the physical property. But the underground property, which represents the greater part of the value of the utility can be inventoried only from the mapped and statistical records. Pipes and valves installed but not shown by the records cannot be included in the inventory. These records are not often audited, but improper record keeping may cost more than improper accounting. Valves are cut into mains because the original valves are "lost"; valves are found closed because there is no record as to whether they opened right or left.

A primary cause of inaccurate or incomplete records is that this work is often considered as a secondary duty, to be given attention only when other work is not pressing. In small systems, the valve record may be only in the head of one or two men, whose loss might thus be disastrous to the utility. Field men often know the location of valves that are not shown on the office records. "It should be expected of the engineer, as of the accountant, that he will keep an accurate and truthful record of his work."

The "comprehensive map"

For effective operation of a distribution system, the superintendent or manager must have a "comprehensive map," giving an accurate picture of the system as a whole, so that he may determine such matters as areas inadequately supplied, whether the mains in a certain area are adequate for fighting a major conflagration, and what may be the best routes for new feeder mains. For daily operation of the system a "sectional plat record" is needed, showing the location of all mains, with their valves and hydrants to permit of economical connection of extensions. Then the crews in the field require small plans of layout of mains, as well as sets of valve measurements in the district where they are working, thus saving valuable time in the closing of valves.

Card records are needed for statistical information and for matters that cannot be shown in detail on the comprehensive or sectional plans. Such information may include service line location, sizes and materials; valve and hydrant types and repairs; leaks and leakage surveys. The records are essentially the same for large and small systems, but the problem of planning and keeping them may be more difficult for the latter, since the man in charge may have a multiplicity of duties.

As the "comprehensive map" is designed to give a clear picture of the water main system, all unnecessary information, such as street or property lines should be omitted. The scale should be as large as possible, using a map preferably 42 in. wide. At 500 ft. to the inch, street names, mains, valves, hydrants, etc., can be shown for a system 20,000 ft. wide. For systems up to 40,000 ft., the minimum scale should be 1,000 ft. to the inch on the same width of map, and this will require very careful drafting. For still wider systems, a wider map may be used, or it may be in

42-in. sections on a scale of 600 or 800 ft. to the inch. This record should be posted semi-annually or annually. The sectional plans may be on a scale of 50 ft. to the inch for small systems; 50 to 100 ft. for congested areas of large systems, or 200 ft. for rural areas. A convenient size is 25 x 30 in.

Separate valve record

Valves are of such importance as to warrant a separate record, giving measurements from reference points, and such details as make, date of installing, direction to open, and number of turns for full opening. In the "plat and list" method, each plat shows a section of the system at 500-ft. scale, covering an area 4,000 x 500 ft. on 8 x 10-in. drawings on sheets 10 x 14 in., with the featured information listed on the opposite sheet. In the alternative "intersecting street" method, with scale of 20 or 30 ft. per inch, on sheets 8½ x 11 in., each plat shows the mains, valves, hydrants, etc., at each intersection, with distances to intermediate valves which cannot be shown. But these records soon become very bulky.

Supplemental maps may include the following, as required: (1) for purposes of analysis at cities of 100,000 or more, an arterial map at 2,000 or 3,000 ft. per inch, showing only the primary distribution mains of 8-in. and larger sizes; (2) valve closure map to indicate any weakness in the valving; (3) a district map where regular leak work is conducted, showing the valves to be closed and the location of pitometer taps; (4) a water gradient contour map, plotted from simultaneous pressure readings over the system during the peak-hour consumption; (5) leak frequency maps, with colored pins to indicate location and type and date of leaks. Defective points will be shown effectively on this map after a few years.

Card records include such details as records of individual valves, hydrants, services, etc., giving all pertinent information. This complete information should be given originally, since a few years later it may take hours to obtain omitted data. Statistical records of property units, for reporting construction progress and growth, may include the following: (1) mileage of mains of each size, posted monthly, with amount laid or removed each month; (2) number of valves and hydrants, summarized and totaled monthly; (3) services installed to buildings or property lines by the utility. Graphical summaries of operation and maintenance work are necessary for measuring the efficiency of the distribution department and are generally included in annual reports. The report states that: "Efficiency of operation can best be judged by comparing the cost per unit of maintenance for different years."

Work order reports

The work-order system for field work of construction, maintenance and repairs is widely used for cost accounting, and should be so extended that complete records of material installed reach the record-keeping department. For a small utility, the work-order summary may be checked against the field sketch, while in a larger utility a duplicate of this summary should be forwarded by the accounting department to the engineering department to be compared with the latter's records. A simple form for field use is a sheet, 8½ x 11 in., printed on one side. On the reverse, a sketch of property line, existing mains, valves, etc., is made in ink by the engineering department, with proposed work shown in pencil. As the work proceeds, the foreman inserts the necessary dimensions and measurements, or makes corrections as required.

Records of work performed are necessary to justify the expenditures, and the committee report gives samples of forms for maintenance and inspection of valves, hydrants, valve operation, services and leaks.

Waterworks of small towns require the same sound management and accounting as the larger systems, and this may be achieved largely by combining certain of the separate records described. For instance, the primary record for a system supplying a population of less than 5,000 may be a detailed map very similar to the "sectional plat," on a scale of 100 ft. to the inch, but having also reference measurements to all valves.

Emergency Chlorination at Rochester

EMERGENCY CHLORINATION measures requiring the use of street flushing trucks, fire department equipment and a hypochlorite solution were employed at Rochester, N. Y. to speed up disinfection of the water system after it was accidentally polluted on Dec. 12. All of this was in addition to the regular and special facilities called into action at the city reservoirs where liquid chlorine was fed to the water.

Following the discovery that a cross-connection valve had been inadvertently opened to permit 4 mgd. of polluted river water to enter the system (*ENR*, Dec. 19, p. 805 and Dec. 26, p. 859), accelerated chlorination was begun immediately at the reservoir. However, tests for residual chlorine showed that the sterilizing agent was not reaching the outlying parts of the 500-mile distribution system.

It was then decided to inject chlorine solution directly into the main using fire hydrant connections as a means of entry. To accomplish this, six 2,500-gal. street flushers and two fire department pumpers were pressed into service. The tanks on the flushers were partly filled with water drawn from nearby hydrants, and to this was added 5 lb. of a high-test hypochlorite powder, containing 70 percent available chlorine; this solution was thoroughly mixed using the pressure pump on the flusher, and then the tank was filled completely with water. The resulting solution contained about 168 ppm. available chlorine.

At various points in the distribution system this solution was forced into the main at 50 lb. pressure by the fire department pumpers. Actual injection of the solution into a hydrant did not begin, however, until a nearby hydrant was opened to flush the main. After two days of this emergency chlorination, during which 67 hydrant injections were made, city and state health officials declared that the pollution hazard was definitely ended.

This information is based on data furnished by the Mathieson Alkali Works, Inc., New York, who supplied the hypochlorite powder used in the Rochester emergency.

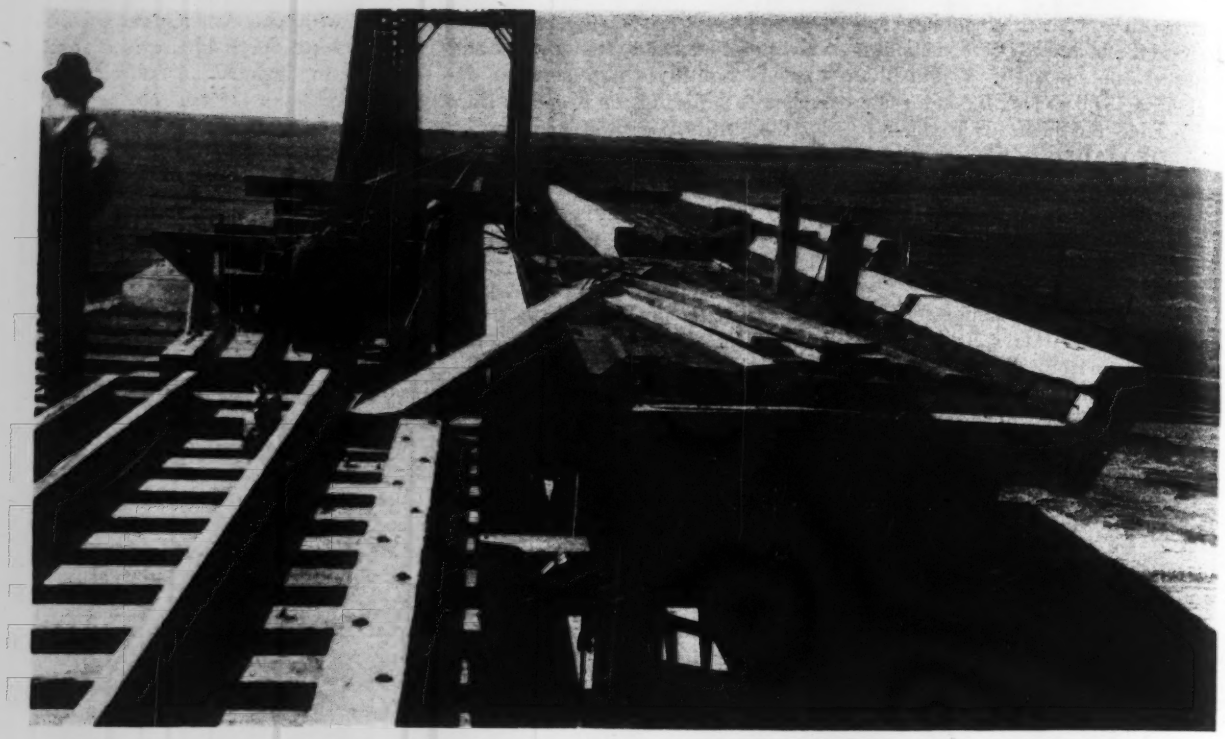


Fig. 1. First shove waiting for track falsework to be removed.

Railroad Girder Spans Jacked into Place

J. Roland Carr
State Highway Department, Cheyenne, Wyo.

***Contents in Brief**—Two deck-girder spans for an underpass on a relocation of U. S. Highway 30 west of Cheyenne were built on falsework alongside the C. & S. Ry. tracks, and were jacked into place between trains. Falsework and jacking arrangements are described.*

AN ATTRACTIVE UNDERPASS of simple deckplate girders, which were erected on falsework and jacked into place, now carries U. S. Highway 30 on a new location under the Colorado & Southern Ry. just west of Cheyenne, Wyo. The single track C. & S. Ry. entering Cheyenne from Denver crosses the four-track main line of the Union Pacific on a through-truss bridge, then continues northward on a high embankment. The new structure replaces an old twin-arch underpass built in 1911, consisting of two 16-ft. dia. arches, each with a roadway width of 13 ft. 10½ in., located about 500 ft. north of the U. P. R.R. tracks. Many accidents have occurred at this inadequate underpass.

The new structure is part of a widening and partial relocation of U. S. 30 westward for a mile from the business district of the city. From the Crow Creek crossing westward the new 4-lane improvement follows the Union Pacific right-of-way, crossing under the Colorado & Southern between the old underpass and the Union Pacific crossing. The new railroad bridge consists of a deckplate girder span 71 ft. 2 in. long, providing a clear span over the new 55-ft. highway, and a shorter side span 38½ ft. long. On top of the girders is an 18-in. concrete slab with curbs to retain ballast.

The south end of the long span rests on the old north abutment of the C. & S. crossing over the Union Pacific, remodeled into a pier by removing the wing walls and part of the back masonry, then adding an 18-in. concrete shell around the remaining old masonry. At the north side of the roadway is a pier, founded on spread footings, carrying the two girder spans. A concrete abutment, founded on concrete piles, at the north end of the short span completes the foundation.

Two sets of falsework

Two separate sets of falsework were required for construction of the new underpass, one to carry the C. & S. tracks, including the north end of the U. P. R.R. crossing during alterations of the abutment and construction of the new pier and north abutment; while a second set was built for erection of the girders alongside the C. & S. track and for jacking them into place.

The track falsework consisted of a triple frame bent at the south or front side of the north abutment of the U. P. R.R. crossing, and three double and six single pile bents; each bent contained six piles or posts. The north end of the Union Pacific bridge was picked up on 10 longitudinal I-beams spanning over the old abutment; elsewhere the track stringers were timbers except for a steel girder span over the new piers between the plate girder spans. The track falsework was driven from track level prior to excavation of the embankment.

For erecting and jacking the two girder spans a double frame bent was built opposite the south abutment, and a double pile bent was driven opposite the pier. A single pile bent was sufficient at the north abutment, as shown in Fig. 3. Ties placed on the bents, and at a corresponding height on the pier and abutments, carried 85-lb. rails placed normal to center line of bridge. The girders were erected on these rails 18½ ft. from final position. On both sides of the pier and the north side of the south abutment frame bents, with caps well below jacking rail level, were built to permit jacking up of the girders to release the rails and ties after the girders were in place. Blocking on the north abutment footing served the same purpose at that point.

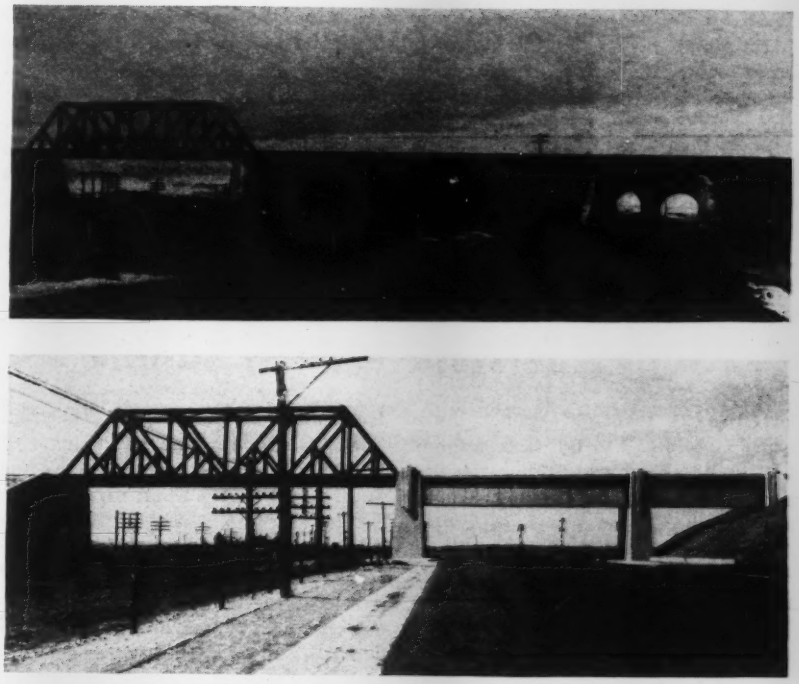


Fig. 2. Before and after improvement which transfers U. S. 30 undercrossing of C. & S. Ry. at Cheyenne, Wyo. from two narrow arch spans to a wide girder spanned opening.

Jacking procedure

The two girder spans were jacked into place, one at a time on two separate days to minimize interference with C. & S. Ry. traffic. A jack thrust block was bolted to the rails just outside of the girder. A 10-ton hydraulic jack, hand-operated, was placed between block and girder at each end, and the girder assembly, carrying the concrete deck, was slowly jacked into permanent position. It was necessary, of course, to remove the temporary railroad trestle opposite each girder span before the girders could be moved into place. There was no coordination in manipulating the jacks at each end of the span except to see that one end did not get too far ahead of the other. As the jacking progressed, additional blocking was placed between the jacks and the original jack thrust blocks.

After the girder spans were on permanent line, they were picked up from the jacking bents while the bearing rail and ties were removed. The girders were then lowered onto their bearing shoes on the pier and abutments. The railroad track was carried over the girder spans on temporary blocking until both spans were in place, when the decks were ballasted.

Direction

The project was under the direction of the Wyoming state highway department, Frank Kelso, superintendent of highways, C. F. Seifried, chief engineer, and W. H. Fisher, bridge engineer, with the cooperation of the Colorado & Southern Ry. and the Federal Road Administration. Jack E. Lloyd, resident engineer, and

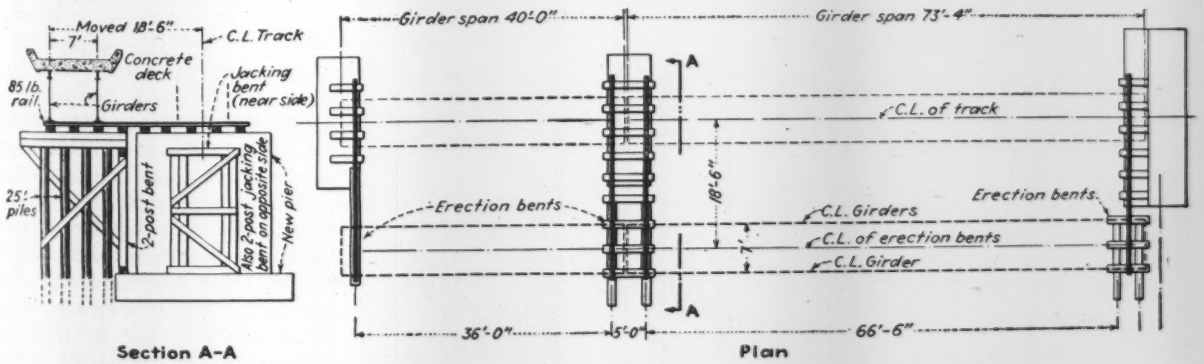


Fig. 3. Layout of erecting and jacking falsework. Track falsework was independent of the jacking timbering.

J. A. Atkins, project engineer, were in charge at the job for the highway department. B. W. Matteson, district engineer at Denver, represented the FRA.

Plans for the bridge were prepared by the C. & S. Ry. under the direction of the late Roy C. Gowdy, chief engineer. Railroad forces drove the track falsework, jacked the girders into position and removed and relaid the tracks.

The Wyoming Construction Co., of Laramie, Wyo., carried out the $85,525 contract for the underpass and approaches.

Treated Water Facilities Supplant Tank Wagon Supply

CITIZENS OF HALLOCK, MINN., have said "Good-bye" to the tank wagons that used to haul water to the town at a cost of five cents a gallon, and are now getting pure water in ample abundance through a filtration plant. The village, situated in an area underlaid by beds of salt, has been confronted for the past several years with the problem of obtaining water suitable for domestic purposes. Due to the presence of minerals underground wells have been failures. Therefore the village depended on the hauling of surface water from some distance away.

The Minnesota State Relief Agency and the village of Hallock combined with Works Projects Administration to construct a filtration and softening plant. The services of Lium and Burdick, consulting engineers of Grand Forks, N. D., were obtained to draw plans for this structure.

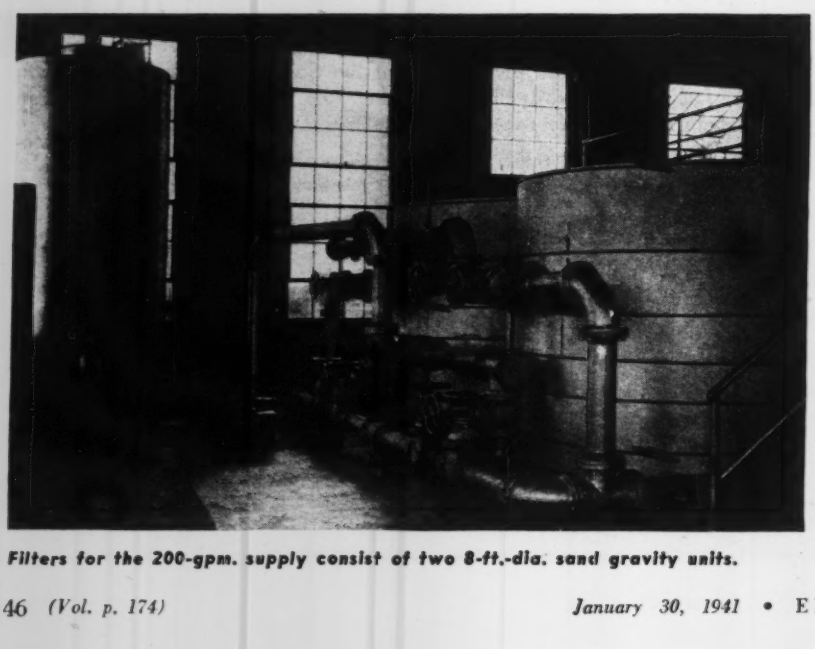
The plant, housed in a monolithic concrete building, was designed to treat water at the rate of 200 gpm. (288,000 gpd). This is adequate to care for a population of 2,880. For future growth, the plant capacity can be increased to 300 gpm. by simply adding one more filter unit.

The lime-soda ash process was selected for softening the surface waters of the type available near Hallock. The complete treatment consists of the following processes:

1. Aeration and flash mix through the use of an air blower and pipe grid. This serves to (a) remove free gases; and (b) mix chemicals.
2. Slow mixing accomplished by mechanical stirring devices in a coagulation chamber. Provision is also made here to add activated carbon for taste and odor removal.
3. Sedimentation in two rectangular basins provided with a system of sludge collecting pipes.
4. Recarbonization takes place in a long narrow basin immediately preceding the filters. This is accomplished by passing the flue gases of the heating plant through the water by means of blowers and pipe grids.
5. Filtration is carried out in two 8-ft.-dia. gravity sand filter units.
6. Ammonia-chlorine treatment for sterilization and also for the purpose of preventing tastes and odors.

From the filter units the water passes to the clear well from which it is pumped to the distribution system and to elevated storage facilities. Total cost of the plant was $82,497 with WPA furnishing $43,869 and the sponsors $38,628; the state relief agency furnished $20,000 of the latter amount. George Nelson of Hallock was the superintendent and Harold Anderson was the WPA area supervisor in charge.

In order to insure an adequate supply of water, two dams were previously constructed, one at Lake Bronson, 14 miles up the Two Rivers from Hallock, and one at the town of Hallock.



Filters for the 200-gpm. supply consist of two 8-ft.-dia. sand gravity units.

Portable Electric Plant For Emergency Pumps

Emergency water-supply conditions that may result from sabotage or aerial attack (*ENR*, July 18, 1940, p. 86) have been provided for by the Mid-Wessex Water Co., in England, by reserve bored wells and electric stand-by pumps at each of its three main pumping stations, together with a portable generating plant. As described in *The Engineer* (London), at each of these stations there has been installed an emergency vertical-shaft, multi-stage deep-well centrifugal pump having a rated output of 1,000 gpm. against a head of 434 ft., and driven by an electric motor.

The portable generating plant consists of a 6-cylinder 225-hp. oil engine and 150-kw. generator mounted on a frame carried by six wheels having pneumatic tires. This trailer outfit is about 20 ft. long, 8½ ft. wide and 12½ ft. high over all, the floor or deck being 3½ ft. from the ground. A one-cylinder air compressor, driven from the main engine, serves for inflation of the tires. For convenience of operation in a dust-laden atmosphere, all moving parts are enclosed and run in oil, while oil-wash air cleaners are connected to the air inlet on the engine cylinders. Screw jacks take the load off the springs when the machine is installed and in operation. This power supply trailer weighs 18 tons and will be hauled by a 40-hp. tractor. The longest distance between the company's pumping stations is 25 miles.

Safety Through Traffic Engineering

Wilbur S. Smith
Traffic Engineer, State Highway Department
Columbia, S. C.

***Contents in Brief**—A traffic engineering division of the South Carolina highway department is carrying on effective accident prevention work by combining close accident recording with directional powers in design, construction, signing and marking. Accident recording is noted for its detail and precision. Construction plans are checked for safety features with special reference to intersections. Advisory service extended to municipalities including data on traffic and street improvements. Experience will dictate the future trends of the program.*

ACCIDENT REDUCTION through traffic engineering is a definite administrative activity of the South Carolina State Highway Department. In 1937, after the passage of a well-rounded safety act by the general assembly, the department added to its engineering organization a traffic-engineering division whose head, designated as traffic engineer, was to report directly to the state highway engineer. As set up, the new division functions interdepartmentally similar to the more familiar construction, maintenance and other divisions. It is believed that a very satisfactory division organization and program have been worked out, and while it is recognized that no one type of organization will suit all state highway departments the one in South Carolina may have interest as one that has been successful.

What the traffic engineer does

In general the work of the traffic engineer is to assist and advise the officials of the department with respect to safety features in the construction and maintenance of highways; markings of highways; collection and analysis of accident reports; promotion of safety on highways, and the general regulation of highway traffic. Specifically he is assigned the following duties and functions:

1. *Accident Reports*—The traffic engineer is responsible for the collection, analysis and filing of all motor-vehicle accident reports.

2. *Construction Plans*—The traffic engineer reviews all construction plans in the P, S and E stage and makes such suggestions as may be necessary to insure that safety fea-

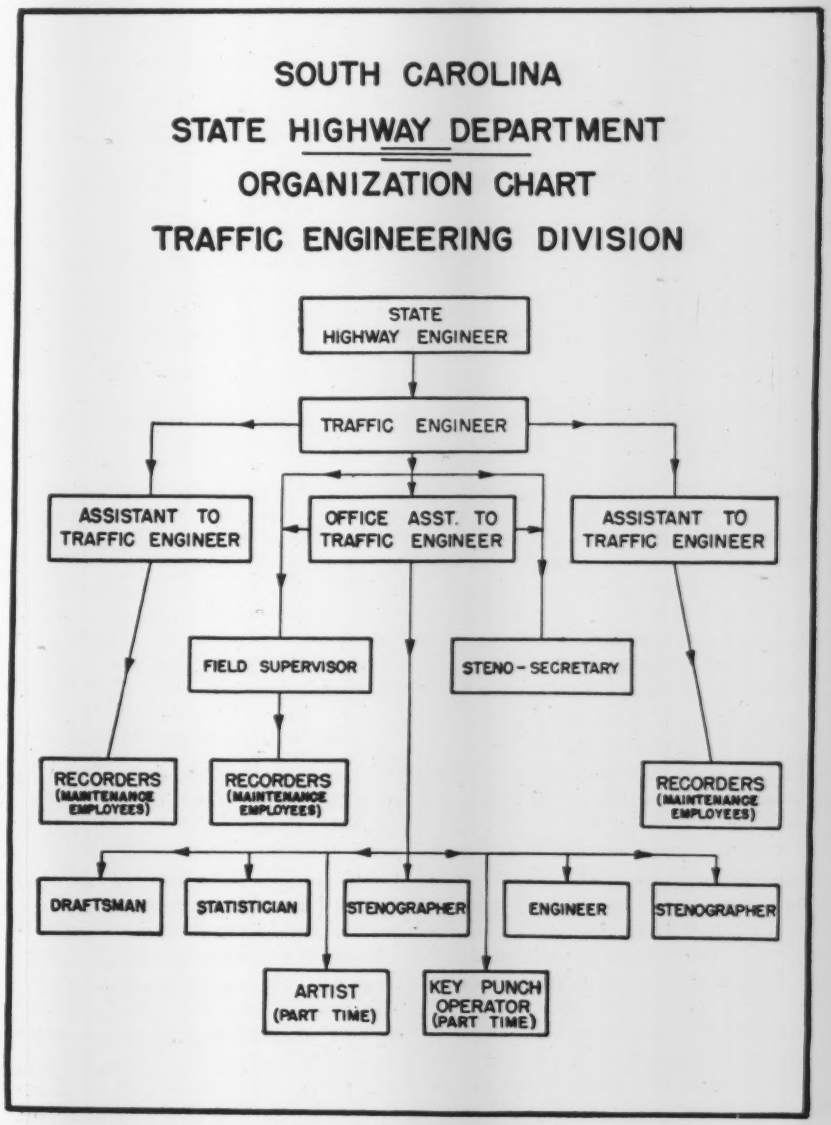


Fig. 1. Traffic engineering in South Carolina is organized as a fully-equipped division of the state highway department having the same interdepartmental relations as have the construction, maintenance or other divisions.

Form 305

CORONER'S REPORT OF MOTOR VEHICLE DEATH

Please give the following information as to motor vehicle accidents investigated by you in the regular course of duty. This information SHALL BE FOR THE CONFIDENTIAL USE OF THE HIGHWAY DEPARTMENT AND SHALL NOT BE ADMISSIBLE IN EVIDENCE FOR ANY PURPOSE AT ANY HEARING OR TRIAL, CIVIL OR CRIMINAL.

Person Killed..... Driver ☐ Passenger ☐ Pedestrian ☐

Address..... (Street) ..... (City)

Age..... Sex..... Date of Accident..... (Hour) ☐ A. M. ☐ P. M.

Date of Death..... Place of Death.....

Location of Accident..... (Street number, or mileage and direction from city or landmarks) ....., in

City..... County.....

Highway No..... County Road.....

Cause of Death.....

Description of Accident and Remarks.....

Date..... Signed..... Coroner

All known information should be given for deaths for which an inquest is pending. These should be marked "inquest pending" Include deaths resulting from injuries and accidents in other counties. Show all deaths resulting directly or indirectly from injuries received in a motor vehicle accident, regardless of the elapse between the time of the accident and the time of death.

Fig. 2. Supplementing the regular accident reports that are required in great detail are reports from coroners, garages and health departments on postcard forms which are analyzed as checking testimony. Note that these reports are for the exclusive use of the department and are not admissible as court evidence.

Form 304

GARAGE OR DEALER REPORT OF MOTOR VEHICLE ACCIDENT

Please fill in the information requested on this card, after receiving for storage or repairing any motor vehicle which has been involved in an accident. This information SHALL BE FOR THE CONFIDENTIAL USE OF THE HIGHWAY DEPARTMENT AND SHALL NOT BE ADMISSIBLE IN EVIDENCE FOR ANY PURPOSE AT ANY HEARING OR TRIAL, CIVIL OR CRIMINAL.

Make of Car..... Registration No.....

Name of Owner.....

Address..... (Street) ..... (City)

Name of Operator..... Operator's License No.....

Address..... (Street) ..... (City)

Engine No..... Color of Car..... Type.....

Date of Accident..... Location of Accident .....

.....

Extent of damage to vehicle..... $..... (Do not include towing charges)

In your opinion will this car be safe for travel after repairs are made?.....

..... (Name of Person Making Report) ..... (Address)

tures are properly provided for in the plans.

3. Road Signs, Signals and Markings—The traffic engineer reviews all specifications and drawings for signs, signals and markings and makes such suggestions as may be proper to insure uniformity and necessary safety features. He makes field inspections of signs, signals and markings to recommend such changes or improvements as may be in proper accord with the prescribed standards of the department.

4. Special Studies of Hazardous Locations—All special studies of hazardous locations for special treatment are conducted by the traffic engineer in cooperation with the district engineers and their assistants. In cooperation with the district engineers he conducts all investigations and studies necessary for establishing restricted speed zones, and maintains a complete record of all such restricted speed areas. Traffic signals and special regulatory signs and traffic-control devices are erected and changed only after complete accident studies and field investigations have been conducted by the traffic engineer in conjunction with the district engineers. The traffic engineer also maintains complete records of the location and types of all traffic signals, or other special traffic-control devices, and before-and-after accident records at these locations.

5. Employees' Safety Activities—The traffic engineer from time to time conducts safety campaigns among the employees of the department.

6. Public Relationship—The traffic engineer confers with and advises municipal and other local authorities with respect to the handling of traffic through municipalities and other political subdivisions. With the approval of the state highway engineer or the chief highway commissioner, he gives such publicity to the subject of highway safety as may be desirable.

Accident reporting stressed

The general-assembly safety act emphasized the investigation and recording of accidents. To this end it made the reporting of accidents compulsory. To carry out the requirements the traffic engineering division makes use of ten forms as follows: (1) accident report form, (2) code sheet, a daily analysis of accidents, (3) accident-report work sheet, (4) drivers' accident record, (5) fatality card, (6) coroner's report of death, (7) garage or dealer's report of accident, (8) health department report of death, (9) tabulating card and (10) statistical summary sheet.

The characters of these forms are

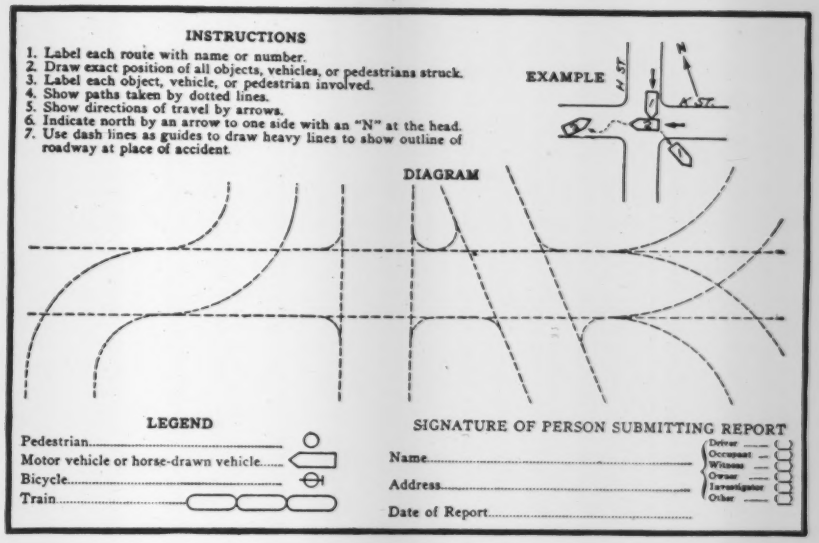
VIOLATIONS INDICATED

(Check all that apply)

	VEHICLE 1	2	3
Exceeding Lawful Speed	☐	☐	☐
Did Not Have Right-of-Way	☐	☐	☐
On Wrong Side of Road	☐	☐	☐
Passing on Hill	☐	☐	☐
Passing on Curve	☐	☐	☐
Cutting in	☐	☐	☐
Failure to Signal or Improper Signal	☐	☐	☐
Improper Turn:			
Wide Right Turn	☐	☐	☐
Cut Corner on Left Turn	☐	☐	☐
Turned from Wrong Lane	☐	☐	☐
Disregarded:			
Officer, Flagman, Watchman, etc.	☐	☐	☐
Stop-and-Go Light	☐	☐	☐
Stop Sign	☐	☐	☐
Warning Sign or Signal	☐	☐	☐
Improper Starting from Parked Position	☐	☐	☐
Improper Parking Location	☐	☐	☐
No Improper Action	☐	☐	☐
Other Improper Driving (Explain)	☐	☐	☐

Fig. 3. Excerpt from an accident report-form showing the detail with which every condition that may have had influence on the accident is checked. This accident report is one of ten forms used in assembly data. The reporting of accidents is compulsory according to state law.

Fig. 4. Beside the written report the accident form provides for and requires a diagram of the vehicle movements before and following the accident.


INSTRUCTIONS
1. Label each route with name or number.
2. Draw exact position of all objects, vehicles, or pedestrians struck.
3. Label each object, vehicle, or pedestrian involved.
4. Show paths taken by dotted lines.
5. Show directions of travel by arrows.
6. Indicate north by an arrow to one side with an "N" at the head.
7. Use dash lines as guides to draw heavy lines to show outline of roadway at place of accident.
EXAMPLE
H ST.
K ST.
DIAGRAM
LEGEND
Pedestrian
Motor vehicle or horse-drawn vehicle
Bicycle
Train
SIGNATURE OF PERSON SUBMITTING REPORT
Name
Address
Date of Report
Driver
Occupant
Witness
Owner
Investigator
Other

well enough indicated by the names. Two of a size capable of being reproduced here are shown by Fig. 2. The vital form is the accident report form. This is a four-page 8½x11-in. document with blanks for indicating some hundreds of items pertinent to an accident analysis. As indicating detail an excerpt from the form is given in Fig. 3; it shows the data required under the classification of violations. Besides the written items of information the form provides for a diagram of the accident as shown by Fig. 4.

Office procedure

Office procedure after the reports and other essential accident data are received in the office is shown in the condensed materials flow sheet, Fig. 5. The flow sheet describes the contents of the sorter file, hold file, driver record file and location file. Most important is the location file, in which reports are placed after all initial analyses are completed. This file provides a quick method for ascertaining the various factors involved in each accident. Preparation of collision diagrams, directional analysis summaries and determination of major contributing accident causes, are dependent upon the reports in it. Locations of high accident frequency may be determined from spot maps, but detailed investigations are contingent upon the location file. Mechanical tabulation is used so that statistical data may be had quickly.

Generally speaking, accident summaries prepared and released to the public monthly are of little value in the actual work of correcting evils. Perhaps their greatest good lies in keeping the problem before the public and stimulating interest in motoring safely. The general factual materials they contain are also useful to safety educators.

From the engineer's point of view, directional analyses, collision diagrams and spot maps are more vital. Our accident system enables us to make the independent studies neces-

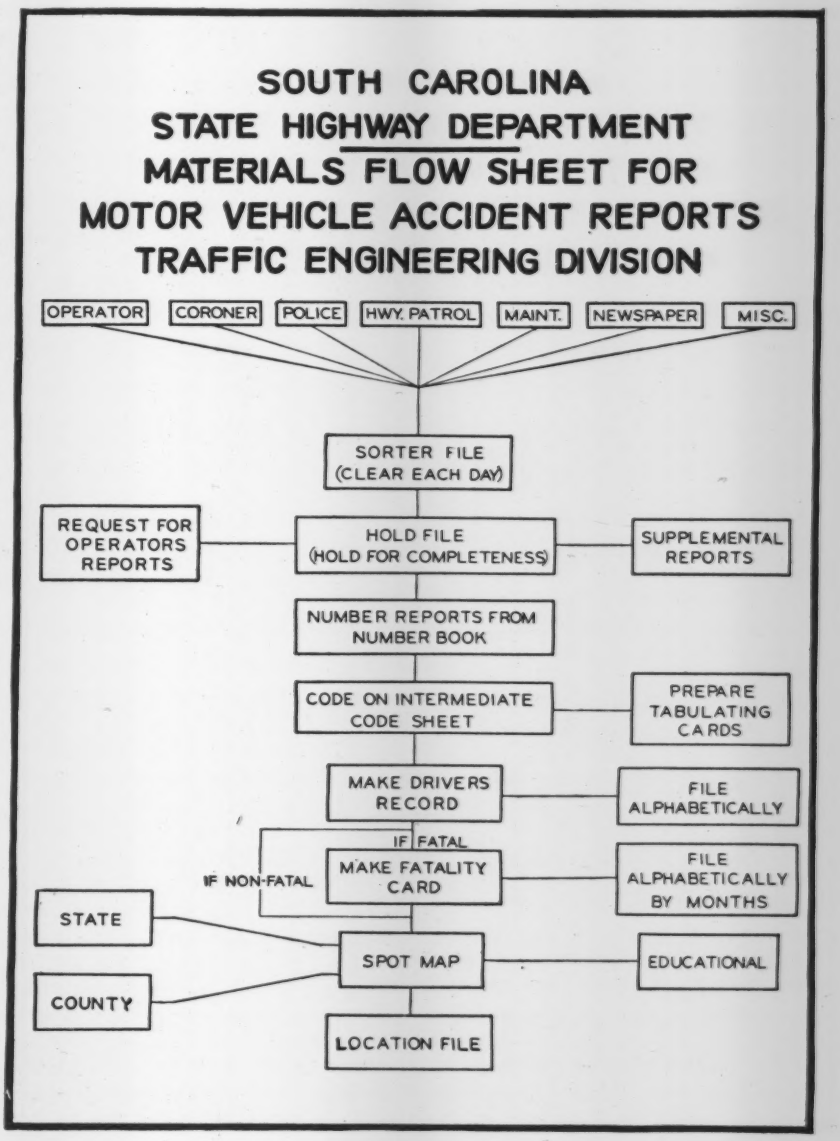


Fig. 5. When the reports of an accident are in, they proceed through the processes of recording and filing as indicated by this flow sheet.

sary to provide safety through engineering. Accident records alone are not sufficient to indicate corrective steps. Studies involving physical conditions, traffic surveys or even psychological influences are needed. Accident records can determine the type of correction; studies of traffic and accidents furnish a measure of effectiveness.

Directional work vital

One of the most important assignments of the division is in relation to construction plans. Field investigations of the general location and of the right-of-way are made in cooperation with the chief of survey and plans prior to actual construction work. During construction other inspections are made. All plans are checked with particular reference to safety features, and changes are recommended if necessary. Particular attention is given to design with respect to intersections, channelization, alignment, grades, lane widths and shoulder widths.

All new signs, signals, and markings are designed or reviewed by the traffic engineering division. In the case of new control devices the location is inspected and traffic conditions studied to determine the proper type of control. All devices must be uniform. When devices are in place, their effectiveness is checked by "after" studies. Effectiveness of many control devices can be measured in terms of their effect upon vehicular speeds. This method affords a much quicker means of determining whether or not the cure is effected than waiting for accident experiences over a long period of time. In rural areas a critical condition may exist at an intersection at which there may not be more than one fatal accident per year. With such a low accident frequency rate, it would take a long time to decide from accident figures alone whether or not the condition in question had been corrected. For the past three years speed measurements have been used extensively in South Carolina to determine whether controls are adequate. To date, in every case in which studies have been applied and recommendations made therefrom, the subsequent accident facts have agreed to a miraculous degree with the anticipated condition.

All special speed zones are required by law to be set up only after a traffic and engineering investigation of the intersection or section of highway designated. Determination of the proper speed by engineering theory and by actual trial runs is made by the division.

Advisory work important

Prior to 1938 the state highway department had no jurisdiction over any streets in towns or cities of more than 2,500 population. At that time an act was passed which, through agreement between these towns and cities and the department, established the responsibility of the department for construction, reconstruction, and maintenance of state highways within cities of more than 2,500 population. Before the department takes over any control, preliminary studies of traffic and accidents on streets used as highways are made, including investigation of volumes, speeds, turning movements, delays, classification, origin and destination, pedestrian volumes and movements, parking, law observance, traffic control observance and accident experience.

On the basis of the studies, the department furnishes the city with a traffic-survey report of traffic and accident conditions on streets used as state highways, with recommendations for changes to facilitate traffic or reduce accidents to be made by the city and the department. Special regulatory devices are suggested if they appear necessary, and in connection with these before and after studies are made of the location in question. Attention is given to relocation, channelization designs or rerouting to eliminate congestion. In the cities surveyed cooperation is given to city officials in bringing traffic regulations up to date and to make their practices conform with standards.

Conclusion

The program briefly outlined is not static, and is not so intended. Experience has indicated that more intensive work will bring worthwhile results. Tentative plans have been made for more comprehensive activity. The plan might be entirely different and still be thoroughly effective. A generally sound principle seems to be to locate the traffic outfit in the department with which it will normally have the greatest number of contacts. However, so many phases of highway work are dealt with by traffic engineering organizations that it appears that in most states the unit should be set up so that its head reports directly to the chief engineer of the state highway department. This enables the traffic division to work with equal ease and effectiveness among the other more established divisions of the department, i.e. maintenance, construction, right-of-way, survey and plans and testing. It is essential that the traffic division is not subordinated in its early stages of development, as this is sure to make its growth slow.

Dike Reservoirs Solve Illinois Water Problems

A dike type of reservoir is being built by Blandinsville, Ill., to provide a dependable supply in a region where water is not to be gotten from wells. This village, whose reservoir, treatment plant and distribution system are expected to be ready to go into operation in March, is making its improvement at an expenditure of about $15,000 less than it would cost to acquire land and build an impounding reservoir on the stream.

The reservoir was constructed by building a dike on four sides of a plot of ground, and the water is to be pumped by a high-capacity pump at the rate of 1,000 gpm. (being operated on automatic float switch) from an adjacent creek. Water flows by gravity through the treatment plant at the rate of 100 gpm. The creek has a drainage area of 3.5 sq.mi. and the reservoir has a 27-million gallon capacity—sufficient storage for six months' consumption and evaporation loss to supply a population of slightly under 1,000.

Blandinsville is the fourth Illinois village to solve its public water supply problem in this way, the others being Mascoutah, Carrier Mills, and Galatia. Despite the necessity for pumping all water to be treated, as well as that lost by evaporation in the reservoir (for Blandinsville the evaporation will amount to about ten million gallons yearly), this added operation cost is offset by cheaper installation cost. State sanitary engineers believe that the dike type of reservoir gives promise of solution of the problems of water supply in many Illinois towns where water is needed and cannot be gotten from wells.

The Three Jewells—
Pioneers in Mechanical Filtration

M. N. Baker
Associate Editor, *Engineering News-Record* (Retired)
Upper Montclair, N. J.

WILLIAM M. JEWELL, last of the pioneers in the distinctively American art of rapid or mechanical filtration of water, died on Nov. 7. Fifty-three years ago William and his brother Ira joined their father Omar in perfecting filters. Although entering the municipal field after the Hyatt, American, National and Warren filters were already established, the Jewell trio soon gained a strong foothold. They maintained their independence during the two mergers of most of their competitors in the '90s but in 1898 yielded eastern territory to the New York Filter Manufacturing Co. and took out a license for the use elsewhere of the Hyatt coagulation-filtration patent.

Omar and William entered the New York Continental Jewell Filtration Co. merger of 1900 under a five-year contract. On its expiration William began independent practice, centering in professional work. Ira had set up for himself before the consolidation. To the patents already in his own name he added from time to time. He built and equipped filter plants and engaged in much litigation. Recently he developed and installed in several filter plants a subsurface filtering and filter washing system. Ira H. Jewell died in 1940, shortly before his brother William.

Omar H. Jewell, first of the Jewell filter trio, was born at Wheaton, Ill., June 1, 1842. He lived to the ripe age of 88 years. As master mechanic for grain elevators he became interested in improving the quality of boiler feed water taken from the notoriously foul Chicago River. Tradition says he built filters in the seventies. The first of his filters seen by William was located in Elevator D, of Armour, Dole & Co., on the South Branch of the Chicago River. Circumstantial evidence points to 1885 as the date of this installation.

Of the scores of filter patents taken out by the Jewell trio, the first ten were granted to Omar in 1888–90. His patent of July 15, 1888, was highly significant for the time in that

Omar Jewell, first of filter trio.

it was for a combination of a filter and chlorine gas generator. The generator consisted of electrodes placed in the dome of the filter tank.

William became chemical engineer of the Jewell Pure Water Co. in 1887, following graduation from the College of Pharmacy, University of Illinois, at the early age of 17. With his father and brother the firm of O. H. Jewell & Sons was formed in 1890. They soon incorporated as the O. H. Jewell Filter Co., which continued in business until the merger of 1900.

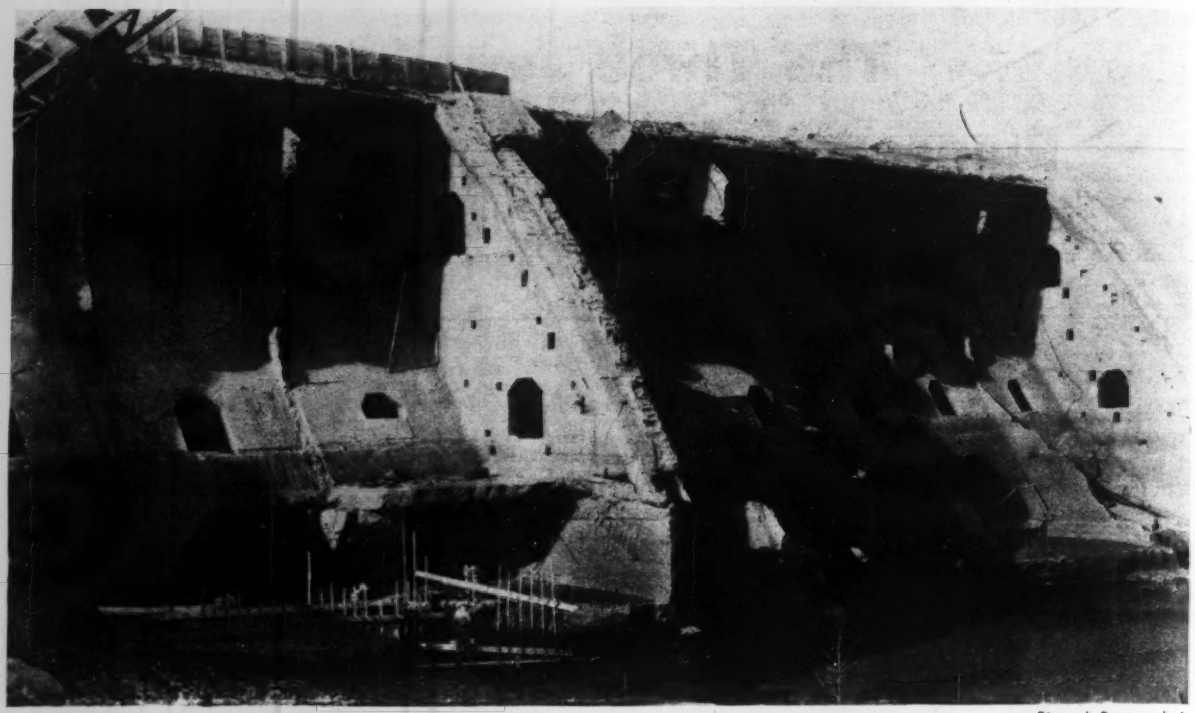
The Jewell Pure Water Co. was largely financed and was managed by James B. Clow & Sons, well known Chicago dealers in waterworks supplies. William Jewell was in Europe in 1887–88 erecting steel tank pressure filters, shipped from Chicago. Apparently these were for industrial plants. The Jewell Export Filter Co. built or equipped filters in many foreign lands. One of the more recent of these was for the city of Warsaw, said to be the largest mechanical filter plant in Europe. It would be interesting to know what happened to it during the blitzkrieg.

The first Jewell filters on a municipal water supply went into use at Rock Island, Ill., April, 1891. Within five years Jewell filters were in use in twenty American cities. (For descriptions of each plant see *Engineering News*, May 21 and 28, 1896.)

Impetus to the adoption of Jewell and other mechanical filters was given by the Providence tests of 1893–94, in which the city was represented by E. B. Weston, and the better-known competitive tests at Louisville in 1895–96, under the direction of George W. Fuller.

An earlier and almost unknown demonstration test at Brockton, Mass., in 1888, would have resulted in an adoption had it not been thwarted by the "advice" of the Massachusetts State Board of Health which had as strong an aversion to the use of alum as a coagulant, as was expressed by Arago fifty years earlier in the review of the art of water purification included in his report on de Fonvielle's pressure filter at Paris. Arago objected to the addition of any foreign matter to water, although he knew it would remove foreign matters already present.

Ira and William Jewell operated the Jewell filter in the Louisville experiments. William, in a letter to the writer, claimed that his filter-rate-controller at Louisville was the first in the field, as also his chlorine-gas producer at Louisville. These producers were based on the conception embodied in the Jewell chlorination-filtration patent of 1888 in which it was said that chlorination could be used separately if desired.



Elwood Payne photo

Fig. 1. These ruins of Austin Dam were salvaged by skillful underpinning and embodied in the new structure.

Underpinning Austin Dam

George L. Freeman
Moran, Proctor, Freeman & Mueser
Consulting Engineers
New York City

Robert B. Alsop
Formerly Superintendent of Construction
Lower Colorado River Authority
Austin, Texas

***Contents in Brief**—Highest overfall dam when built in the 90's, Austin Dam soon met disaster from sliding out and undermining because of bad foundation rock. In spite of rebuilding and patching it has stood a useless ruin during most of its half century of existence. Two years ago, when final reconstruction was begun, great voids were found under its base. A hazardous job of underpinning, followed by deep grouting, was necessary before the superstructure could be rebuilt.*

AFTER 50 YEARS of disastrous experience marked by failure on failure, due to treacherous foundation conditions coupled with inadequate design and construction, Austin Dam across the Colorado River of Texas has been rebuilt on solid support. This undertaking, leading up to dedication of the dam last April, required an underpinning operation of extraordinary kind. The entire history of the structure illustrates a half century's advance in engineering practice and construction methods applied to foundations in bad rock.

The damsite, on the Colorado River three miles northwest of the center of Austin, is in the area of the Balcones fault zone, the dam being on the downthrow side of a series of multiple faults. The Edwards limestone here lies nearly horizontal, dipping 3 or 4 ft. per 100 ft. downstream in beds up to a few feet thick. The rock varies from soft to very hard, is extensively fractured, contains many open or clay-filled seams, and is traversed by solution channels and caverns. Springs at various places testify to the flow of water through the rock.

In the face of these conditions the original dam had been founded virtually on the surface of the riverbed rock. This fact, together with absence or deficiency of grouting and cutoff construction and with deficient superstructure design, gave rise to most of the trouble that marked the history of the dam.

A succession of failures

Conceived in 1890 as a water supply power project by the city authorities, the dam was completed in 1894. It was a masonry overfall dam 60 ft. high above low water or 68 ft. above foundation, and 1,091 ft. long. Well known engineers con-

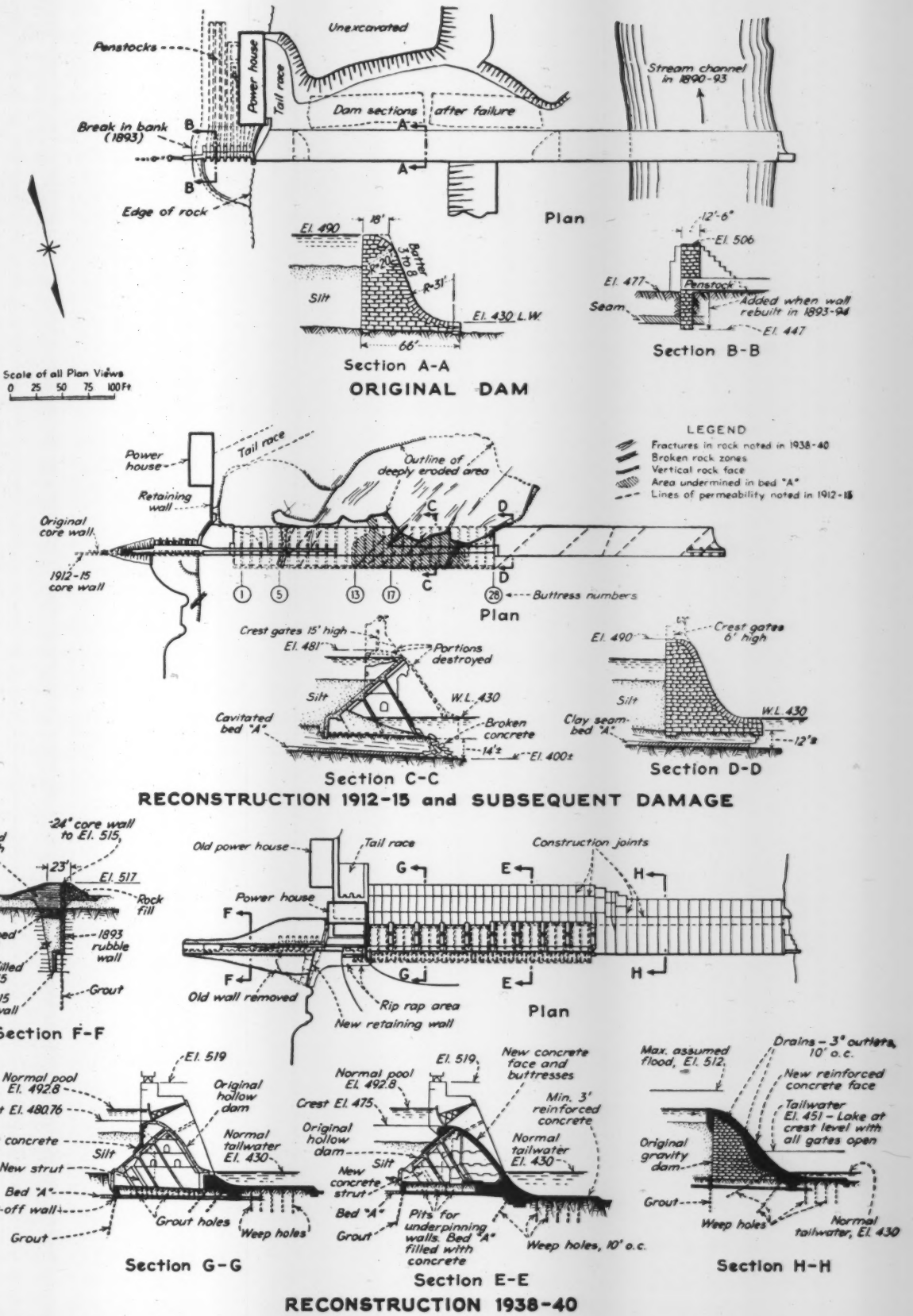


Fig. 2. Fifty years of Austin Dam history illustrating the various types of construction used for the structure from its original design in 1890, through the 1912-15 repair, and the final reconstruction carried out during 1938-40.

Fig. 3. Worst conditions were found under the hollow dam near buttresses 19 and 20, where toe erosion had washed out a thick clay seam (Bed A) underlying the layer of rock on which the dam had been built. Location of these buttresses is shown in Fig. 5.

nected with its design and construction included J. P. Frizell, J. T. Fanning and John Bogart.

Construction had to contend with frequent floods, bad rock, springs and underflow, and several failures of headgate masonry. Nevertheless the dam served for nearly six years after completion. Two vertical turbines operated pumps to supply the city water system, and four pairs of horizontal turbines drove electric generators; the installation totaled 2,400 hp.

Apparently no core drilling had been done before construction, and no deep cutoff or grout curtain was provided. The dam was too narrow to resist pressure and uplift safely, and under flood conditions and the added pressure of a deep deposit of silt which soon formed on the upstream side it was subjected to an estimated friction factor of 1.23. Also, nothing was done to protect the rock at the toe from erosion. Undermining was observed within three years: in 1897 a fisherman was able to run his fishpole 8 ft. under the toe of the dam, and in the same year boils of water were seen just below. Later various leaks were discovered and plugged.

On April 7, 1900, the dam failed during a flood that was running 11 ft. deep over the crest. A length of 500 ft. slid out, in two sections, which remained upright and stood at almost their original level; in the gap several feet of rock under the dam were gone. The failure left the city without water, light or power.

Twelve years later rebuilding was begun, after a number of core borings 30 to 40 ft. deep had been drilled at the site. These, it was reported, showed alternating moderately hard limestone, soft adobe, and cavities. A hollow buttress dam of reinforced concrete was built in the 1900 gap, its crest 9 ft. below that of the remaining masonry dam, and gates 15 ft. high were placed on top, with correspondingly lower crest gates on the masonry dam. Buttress footings were carried to the first stratum of hard rock encountered. Shallow cutoff walls were put in and the foundation was grouted 5 to 11 ft. deep.

Reconstruction was completed in 1915, after many accidents and interruptions, the last being the carrying out of four crest gates shortly before work was completed. Soon afterward, however, another flood carried out 20 crest gates and blocked the tailrace and draft tubes of the powerhouse with debris. For 25 years thereafter, no power was produced at the dam—until 1940, when the dam as rebuilt with adequate foundations was completed.

In 1917 Daniel W. Mead investigated the dam, but no action was taken on his report. Finally, on June 15, 1935, a flood greater than any of record and three times as large as the one that wrecked the original dam in 1900 flowed 25.4 ft. deep over the crest of the hollow dam, tore out all but three of the crest gate piers on the gravity dam and more than half of those on the hollow dam, and broke away part of the crest slab. Over 200 ft. of the downstream face slab tore away subsequently.

Such were the conditions when, in 1937, the Lower Colorado River Authority proposed to rebuild the structure as a unit in its series of power dams on the river. Before proceeding with the project it asked the firm of Moran, Proctor, Freeman & Mueser, consulting engineers, New York, to make a thorough engineering investigation of site and structure and outline a feasible procedure of reconstruction.

Exploring the foundation

The investigation included core borings 70 to 200 ft. deep, examinations by divers, soundings, and tests of materials. Leakage tests were made in all bore holes with

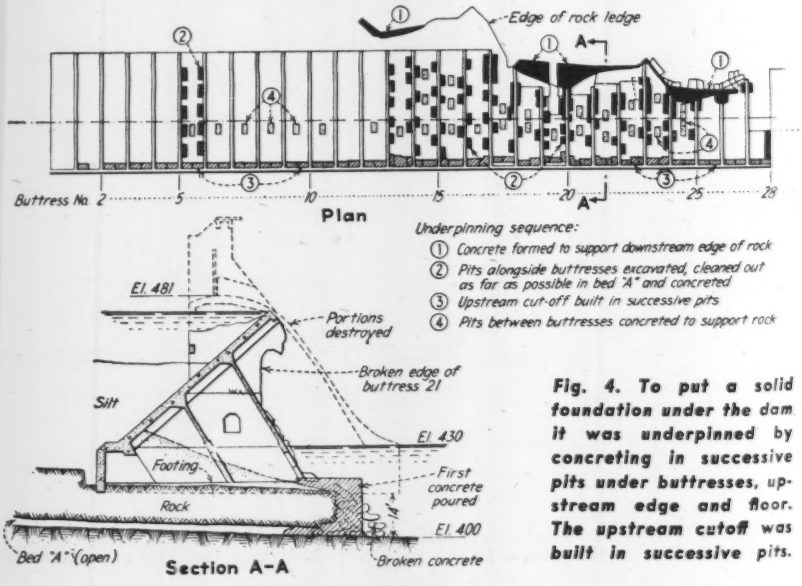


Fig. 4. To put a solid foundation under the dam it was underpinned by concreting in successive pits under buttresses, upstream edge and floor. The upstream cutoff was built in successive pits.

the help of a double stopper device.

The survey confirmed and greatly extended earlier information on the poor quality of the rock under the east half of the dam, revealing deep-lying pervious zones. It also showed that a large area of the dam was undermined and was held up only by occasional pinnacles of rock. Erosion downstream of the buttress dam was found to extend 10 to 15 ft. below the level of the buttress footings, to the bottom of a clay seam (Bed A) which lay below the upper stratum of hard rock. Practically all the surviving deck slabs of the hollow dam showed extensive cracks.

However, the survey showed no settlement of the dam, and the strength of the foundation rock proved to be satisfactory, even the weakest layers showing test strengths of 3,000 lb. per sq.in. The concrete of the buttress dam was found to have a crushing strength of 3,000 to 4,000 lb. per sq.in., and the mortar of the masonry core of the old gravity dam a strength of 2,320 lb. per sq.in.

Silt had accumulated above the dam nearly to crest level, and tests showed this silt to exert a lateral pressure approximating that of a liquid weighing 85 lb. per cu.ft. The report recommended that a wider and stronger gravity section be built. Both gravity and hollow dams required cutoff construction and thorough deep grouting with extensive underpinning under the hollow dam. It was considered advisable that the base of the structure be shouldered against the rock strata downstream in such manner as to have a dependable abutment capable of taking the full thrust. With these provisions, practically all surviving parts of the structure could be utilized.

A difficult underpinning job

The most critical element of the operation was underpinning the hollow dam, much of which was known to be undermined. Before this work could be attempted the gravity dam was cofferdammed, reconstructed as shown in Fig. 2, Sect. HH, and cut through by a 25-ft. diversion slot down to tailwater level, so that the hollow dam could be reconstructed after diverting the river through the slot.

In this operation the crest masonry of the old gravity dam was removed to a depth of 5 ft. and replaced by a concrete crest built 2.8 ft. above the original crest level. This new concrete crest section was carried downstream to form a flattened downstream slope which gave the dam sufficient stability to resist safely a flood of 500,000 sec.-ft., 19.2 ft. deep over the crest—this with uplift over the entire base area equal to full head at the heel and tailwater head at the toe. Five longitudinal drains were placed in the plane of contact between concrete and old masonry, with 3-in. outlets 10 ft. on centers leading to the downstream face.

Under the upstream edge of the gravity dam a concrete cutoff wall 4 ft. thick (Fig. 5) was carried down through Bed A, to eliminate all leakage to that level, and below this point the foundation rock was grouted to a minimum depth of 60 ft. below top of rock. Simultaneous with this work the west abutment was strengthened and extended, and an end cutoff built 10 ft. into the cliff with a grout curtain extending 50 ft. farther.

No attempt was made to unwater the undermined hollow dam—particularly between buttresses 17 and 28, where crest and downstream deck slab had been carried away—until the pond had been drawn down to eliminate as much thrust as possible. Even then there remained the thrust of 35 to 50 ft. of silt.

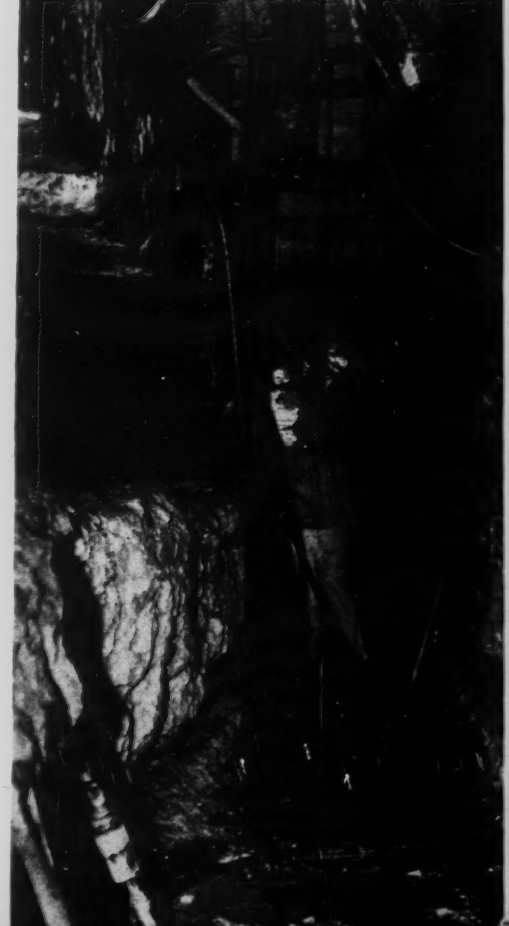
When the cofferdam below the structure was unwatered and the conditions shown in Figs. 1 and 3 could be seen, with the silt-loaded dam towering 60 ft. above, it was difficult to understand how the structure still stood. No work could be done on the structure until some support had been provided along the downstream edge of the unsupported rock shelf.

Most of the buttresses between 17 and 28 had broken back to the first inclined wall, and at one buttress the downstream end of the footing had separated from the concrete above. Several footings apparently had been founded directly on the rock surface. Just downstream of the toe, the river-bed rock was eroded deep below the footings of the dam. As the rock bench on which the dam was founded stood 15 ft. above the floor of the eroded area, it was evident that no cutting of masonry or removal of rock could be attempted until this threatening condition had been corrected.

As an emergency measure, after the thin layer of mud on the rock floor had been washed away we immediately set up a vertical form 4 or 5 ft. away from the broken edge of the rock shelf and poured in concrete back of it (Fig. 4), letting it flow under the unsupported rock as far as it would. The edge of the broken rock being thus supported, the slow work of progressive underpinning could begin.

We proceeded to underpin the buttresses by excavating pits alongside each and clearing out Bed A under each pit as far as could be reached, then concreting, letting the concrete flow out into Bed A as it would. The pits were sunk in succession until the full length of each buttress was supported. Buttresses 13 to 27 and also buttresses 5 and 6 were thus underpinned. The remaining buttresses east of 13 were given solid support by drilling holes alongside them 5 ft. apart and injecting grout

Fig. 5. A cutoff wall was built along the heel of the old gravity dam to embed its base course (upper left) and seal the strata to below Bed A (bottom left).



into Bed A to fill any cavitated space. Generally, in this region, Bed A was filled with firm clay capable of supporting its load if confined by an effective upstream cutoff.

After the buttresses were underpinned the upstream cutoff wall was constructed under the hollow dam, working from beneath the dam. The cutoff was built by excavating successive pits to Bed A, and the concrete again was allowed to spread out as far as it would in this bed, forming both a cutoff wall and an upstream support. The last operation consisted of excavating additional pits between buttresses to give sufficient support for the rock itself above Bed A.

While it is not believed that all of the cavitated space between buttresses 13 and 27 has been filled with concrete, we are certain that adequate structural support was provided, and special care was taken to insure a tight upstream cutoff wall.

Superstructure rebuilding

With completion of the underpinning and cutoff wall, the critically difficult element of reconstruction of the hollow dam was accomplished. Very extensive and complex work had to be done on the superstructure, but the dam as such was secure. Now the broken buttresses were trimmed back to sound concrete and extended to support a new downstream deck, the extension, 2 ft. thick, being lapped back over the old buttress concrete. At intervals of 60 ft. along the dam, 9-ft. piers for the Tainter gates were constructed in slots cut through the existing deck; these piers as well as the buttress extensions were carried to sound rock below Bed A, and to greater depths where drill holes revealed clay pockets below.

A continuous toe block of mass concrete was shouldered into sound rock for a sufficient depth (at least 8 ft.) to take the full thrust against the dam at 15 tons per sq.ft., and in addition a 3-ft. apron toed 5 ft. into sound rock was built downstream. Similar thrust and apron construction was done below the gravity dam.

The overhanging part of the original crest slab proved to be in danger of failure by uplift under flood conditions, as apparently had happened on part of its length in the 1935 flood. Also all upstream deck panels were overstressed under flood conditions. For this reason a vertical wall was constructed under the overhang east of buttress 17 and the space behind it vented to relieve any hydrostatic pressure. West of buttress 17 the two upper panels were strengthened by additional deck concrete, drain holes being drilled through the original deck slab to relieve it of hydrostatic pressure. The lower upstream panel of the deck slab for the entire length of the hollow dam was stiffened by adding an intermediate support in each bay, a T-strut carried down to firm rock.

Grouting the foundation

Under the entire length of the dam and the east dike a grout curtain was put in as a barrier against water movement, grouting being done to a minimum depth of 60 ft., increasing to over 100 ft. under the east dike and across the badly fractured zones under the dam. Tedious, careful work was required because of the broken and pervious nature of the strata.

The initial grout holes, 2¼ in. in diameter, were spaced 5 ft. on centers and were vertical except under the hollow dam where the drilling was done from the rock floor under the dam. After drilling, each hole was carefully washed with a special nozzle having a rectangular side outlet which, under a pressure of around 200 lb. per sq.in., would deliver water in a horizontal jet with sufficient force to cut and dislodge clay in the intercepted seams and pockets. By washing out the seams from hole to hole, to permit the entrance of grout, an effective curtain was produced.

Necessarily, the washing was a slow operation; one hole, for instance, had to be washed for 24 hr. before it was satisfactory for grouting.

After the cutting jet had been used in a series of holes, they were blown out with air and water under high pressure to expel as much mud as possible. This blowing frequently showed interconnection through a row of holes extending over a distance of 50 ft. or more—proof of the effectiveness of the cutting jet.

Grouting with neat cement and water was done in stages, the holes being first drilled and washed to Bed A, which was grouted tight under a pressure of 30 to 50 lb. per sq.in., then drilled to additional depth, washed and grouted, until reaching the final depth. Pressures up to 150 lb. were used in the deeper holes. Some of the holes took nearly 5,000 sacks of cement each, and one hole, which took 3,600 sacks, had to be drilled and grouted nine different times.

In the two broken zones under the hollow dam, intermediate holes were drilled between the original holes, and before the curtain was satisfactorily formed the holes frequently were only about 1 ft. apart. On the other hand, the gravity dam and the east dike required few intermediate holes. In all the grouting, 2 percent of calcium chloride was added to the cement to accelerate the set.

The total amount of drilling, washing and grouting required in this operation was tremendous, mainly because at several points the crushed rock zone extended to great depth —actually an unknown depth. In all more than 86,000 lin.ft. of drilling was done for the great holes, and about 80,000 bags of cement were consumed in the operation.

Other operations

The most troublesome feature of the dam throughout its history, aside from the foundation, was its junction with the east bluff. Washouts and leaks had occurred here repeatedly, and two separate attempts had been made to seal the junction by a deep cutoff wall under the headgate structure. Much exploratory work was necessary to determine the character and extent of this cutoff wall, the deeper part of which had been constructed in 1912 to 1915. After thorough exploration the wall was deepened by a grout curtain and extended farther into the bluff. The grout holes were drilled 5 ft. on centers down through the core wall to a depth of 100 ft. below rock.

East of the new intake a reinforced-concrete cantilever retaining wall was constructed to retain the upstream fill of an earth and rock dike covering the old headgates. This dike was made of impervious soil upstream of the wall and of rockfill downstream. The earthfill was placed in 6-in. layers at optimum moisture content (about 12.5 percent) and rolled by sheepsfoot rollers under Proctor control to a density of 133 lb. per cu.ft.

In the reconstruction of the powerhouse, which is of normal arrangement (see *ENR*, June 20, 1940, p. 53) and contains two adjustable-blade propeller turbines of 10,000 hp. each, the chief unusual feature is the design of the exterior walls. These were proportioned to resist external pressure due to tailwater for a height of 34 ft. above the generator floor. The downstream and river side walls were designed to act as cantilevers projecting upward from the mass concrete.

Throughout the work on the dam the deep silt accumulation on the upstream side was disturbed as little as possible. Adjacent to the hollow dam the silt blanket was removed only deep enough to allow of placing the new concrete on the upstream deck. Along the gravity dam, however, it was necessary to construct the cutoff wall and grout curtain within the protection of steel sheet-pile cofferdams; the muck within each cofferdam was excavated to rock but was backfilled promptly as the cofferdam was removed.

An outstanding feature of the entire construction was the extensive cutting and removal of rock and old masonry by pneumatic hammers and pavement busters. Powder was used only in removing some of the masonry from the old gravity dam. No shooting was permitted in the rock excavation or in the preparation of trenches to receive new concrete. Pavement busters did most of the work, about 50 of them being in operation for many weeks.

Personnel

Design and construction of the entire work were carried out by the Lower Colorado River Authority, Clarence McDonough general manager, and Robert B. Alsop superintendent of construction. C. S. Adams was designing engineer in charge of preparation of plans and specifications, and G. F. Harley was in charge of the PWA staff. Moran, Proctor, Freeman & Mueser were consulting engineers throughout the exploration, design and construction, with George L. Freeman in charge and John D. Sillenbeck as representative on the work.

Safe Plumbing—A Laboratory Tells All

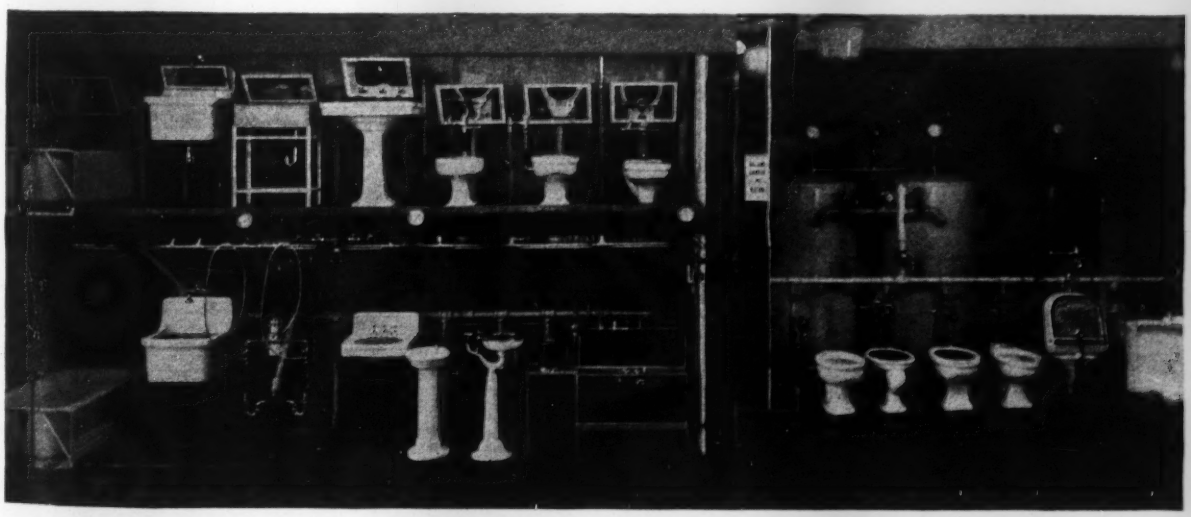
A Plumbers Convention Exhibit of sanitary fixtures inspired the water pipe extension division of the Chicago bureau of engineering to set up a laboratory for testing fixtures and appliances submitted by manufacturers. The purpose of the laboratory is to discover and prevent the possibility of water contamination through cross-connections or back siphonage.

In addition to acquainting the public with the work carried out to prevent spread of waterborne disease and pointing to the need of safe plumbing installed in accordance with the new building code, the tests and demonstrations also constitute an educational program for training employees.

The accompanying photograph shows the testing rack at right with high pressure tank in rear. A pressure of 100 lb. per square inch can be developed in this tank by operation of a high-pressure pump and a compressor which are installed in the basement of the building.

The other two tanks shown permit the creation and maintenance of a vacuum up to 28 in. by operating a pump in the basement. This equipment and the unit to the left enable the operator to make pressure and back pressure tests, create a vacuum in fixtures and demonstrate the effects of siphonage, cross-connections and other dangerous conditions.

A harmless dye is used to color the water and represent the contaminated fluid as it passes from one fixture through transparent tubing into the water supply lines to other fixtures. Back siphonage may be seen in the transparent riser, shown in center of photograph, as water fills the pipe under pressure and then drops rapidly when a 24-in. vacuum is created by shutting off the central valve to the riser and opening at faucet or valve in the basement.



This is not a sales exhibit but the plumbing testing laboratory of the Chicago bureau of engineering.

Fig. 1. Precast conduit units with hinged joints used in a Danish outfall sewer.

Novel Joint Simplifies Sewer Construction

R. Hafdan-Nielsen
Chief Engineer, Monberg & Thorsen
Copenhagen, Denmark

***Contents in Brief**—An ingenious method of laying an underwater sewer using a hinged joint has been developed in Denmark. Precast concrete conduits 50 ft. long and weighing 44 tons were easily assembled with simple equipment. Of special interest is the use of packing material of wood fiber which is compressed to solid wood when the joint is made up.*

INSTALLATION of a concrete box sewer underwater was greatly simplified by the use of a novel hinged joint which permitted the quick assembly of precast units. These units, 50 ft. in length and rectangular in cross-section (10.17x3.58 ft.) contained three interior vertical partitions which formed a four-chamber conduit. A joint packing of wood fiber rope was compressed in place by the hinge action secured in laying the units.

This outfall sewer serves a suburb of Gentofte, north of Copenhagen, Denmark. Its size as well as the method of joint construction are quite different from anything in American practice recently described in *Engineering News-Record* (see outfall sewer series, Nov. 23, 1939, p. 689; Dec. 7, p. 764 and Dec. 21, p. 846).

The sewer has a total length of 5,000 ft. It is at a depth of 15 to 27 ft. below the water at the pumping station and outlet, respectively. Throughout its length it was placed in a 6-ft.-deep trench. It has been in operation for about two years.

Details of unit

Monberg & Thorsen, engineers and contractors of Copenhagen, developed the special method of placing the sewer units (Fig. 3) which called for the use of a simple but effective jointing method. The 50-ft.-length reinforced concrete units have outer walls 4 in. in thickness, and the partition walls are 3¼ in. thick; each unit weighs 44 tons.

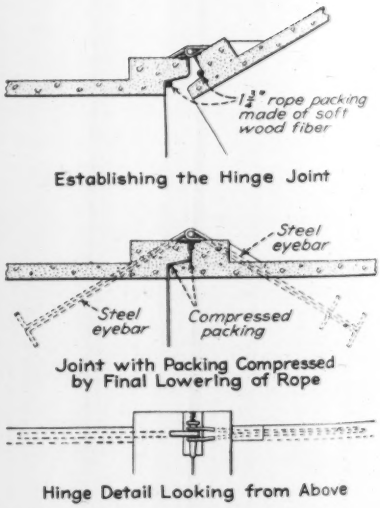

1¾" rope packing made of soft wood fiber
Establishing the Hinge Joint
Steel eyebar
Steel eyebar
Compressed packing
Joint with Packing Compressed by Final Lowering of Rope
Hinge Detail Looking from Above

Fig. 2. Details of the hinged joint.

Details of the joint design are shown in Figs. 2 and 4. The joint

seal consists of a double packing of 1¾-in. rope made of soft wood fibers. Each end of the unit is provided in its upper corners with steel eyebars well anchored in the outer concrete walls. These form the hinges for interlocking the unit, and also served as a means of hoisting them.

To manufacture the units a pouring plant was established on a vacant harbor pier (Fig. 1). The 100 units needed for the sewer were poured in two sets of steel forms erected on a floor covered with steel plate. Sufficient space was provided for 8 pouring units at a time.

The inner 50-ft. forms were constructed in such a way that they could be contracted ½ in. to facilitate their removal. The manner in which the form was pulled out—one half to either side—is shown in Fig. 1. After the unit was cured for one week it was stored at the waterfront.

Each unit was then fitted with packing (Fig. 4) and watertight wood covers were bolted on both ends.

Placing the units

The trench foundation work for the sewer was carried on in advance of the placing of units. Two types of foundation were used. Where the bottom was very hard clay, two concrete ties, one at each end, were placed in accurate position to receive the unit. On a section near shore, where the bottom was soft, wooden piles were driven and fitted with 9x9-in. crossties (Fig. 3).

From the pouring plant the units were towed over the trench where they were received by a twin barge rig. Here a unit was fastened to two differential hoists. After the wood covers were removed the unit was ready to be lowered into final position. How this operation was carried out is shown in Fig. 3.

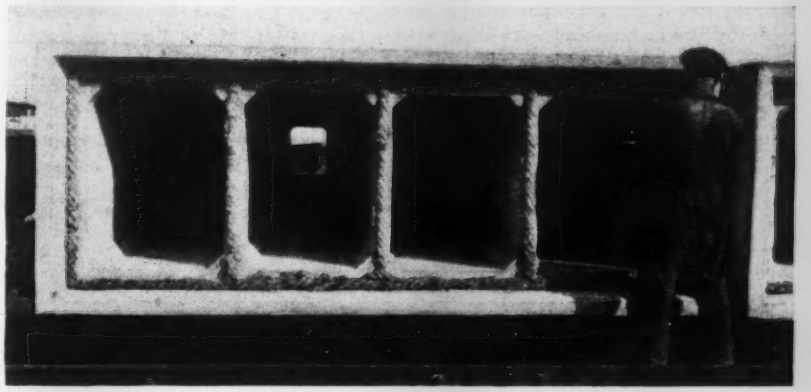


Fig. 4. Double packing of 1¾-in. rope made of soft wood fibers was placed in the joint at both ends of the precast units.

Joining pipe sections

The end to be connected to the unit already in place was lowered well ahead of the other end. Two divers directed the lowering and established the hinges by placing the pins. The unit was then lowered into final place by revolving it around the hinges. This last move established the joint and compressed the packing to a consistency of almost solid wood.

It must be realized that a very considerable turning moment (50,000 lb. x 25 ft. = 1,250,000 ft. lb.) was available to accomplish the compression of the packing. The hinges were designed to resist a pull of 15 tons each. A successful joint called for great accuracy in placing hinges as well as in forming the concrete joint. This was made possible by the use of steel forms.

Success in fitting the joints depended also on careful alignment of the foundation. If, for instance, the concrete tie at the end away from the hinge was placed 1 in. high or low, the closing of the joint at bottom of sewer would vary about $\frac{1}{16}$ in. in lesser or greater tightness. Consequently the packing rope would be compresed a little less or a little more, than would be the case where exact levels were obtained. No difficulties were encountered, however, in securing the required accuracy.

Joints permit curvature

Near shore the pitch of the sewer followed a circular, vertical curve. Joints were easily adjusted to meet this condition by slanting the joint form slightly before the unit was poured. To do this a thin wedge was inserted between the end and side forms.

With favorable weather conditions two units were placed each day and foundations were prepared by the

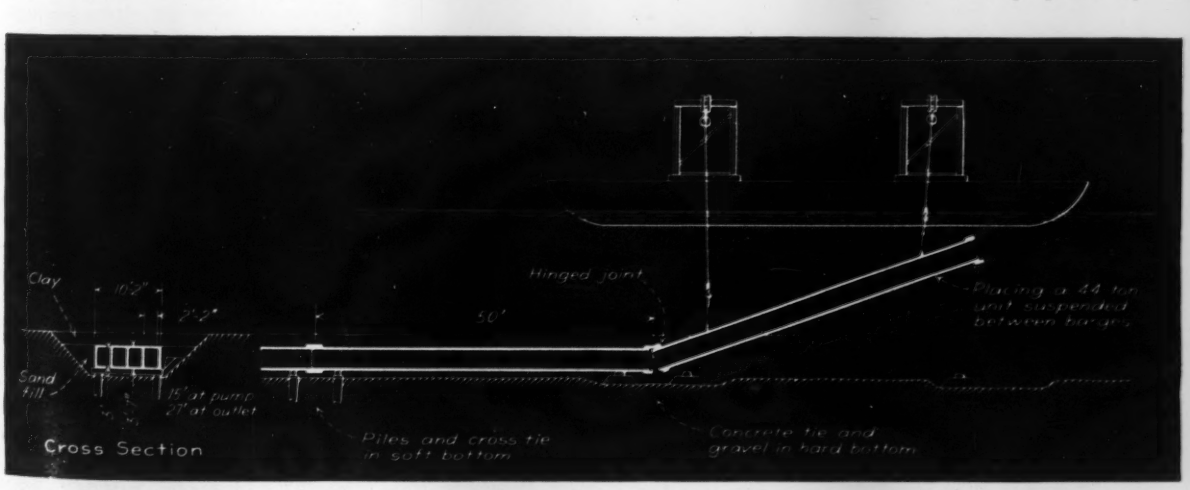


Fig. 3. Method used in laying the rectangular units. Assembly was simplified by using hinged joints with fiber packing.

same crew. When the sewer was placed the trench was backfilled with fine sand, and then covered with a blanket of clay.

The reason for dividing the sewer into four separate chambers was to reduce pumping costs. Each chamber is served by its own pump, and the number of pumps engaged can be arranged to suit the sewage flow. In this way a rate of flow can be maintained which will keep the sewer clean. Each of the four pumps and a standby unit, has a capacity of 10,000 gpm. The sewer has been designed for a maximum capacity of 40,000 gpm.

Careful consideration was given the choice of packing material. It was decided that the constant overpressure in the sewer would eventually blow out asphalt mixtures. The wood fiber rope, on the other hand, is absolutely durable, and has proved to give a very tight joint when compressed to a degree where voids are eliminated.

Court Upholds Contractor's Claim For Unforeseen Subsurface Obstruction

Frank Weinstein
Weinstein & Levinson, Attorneys, New York

ANOTHER CASE bearing on the involved question of whether the extra cost arising from unforeseen underground conditions shall rest on the owner or the contractor has been decided by the New York Court of Appeals, the highest judicial tribunal of the state, in favor of the contractor.

This case (McGarry Contracting Co. vs. The Board of Education of the City of New York) related to a contract for the foundation work and excavation for a public school on 113th St., New York. There was no indication in the record of borings nor in the plans and specifications that the contractor would encounter any unforeseen difficulties in making the necessary excavations. It developed, however, that the contractor, while making excavations for his footings, found massive old foundation walls which the inspectors insisted upon having removed. This extra work made the actual cost of foundation construction about twice what the contractor originally estimated. The contractor brought an action to recover this extra cost. It was resisted by the Board of Education, who claimed that the contractor assumed this extra work by the express provisions of the specifications, which provided as follows:

> 4. (d) Any diagram, chart, plan or description of borings or other subsoil data which may be submitted with the drawings shall not, because of the well understood difficulties under which such borings and subsoil explorations are made, be held to be final and conclusive. The Board of Education shall not be held responsible for any differences between the indications shown on the diagram, chart, plan or description of borings or other subsoil data and the actual subsoil conditions that are disclosed by excavation. No damages or additional compensation shall be claimed by or paid to the contractor for any differences in the character of earth to be excavated or for any pumping that may be required. Any and all changes in foundation work made necessary by such differences in subsoil conditions will be paid for as provided in Par. 45 (b) of these specifications.

The contractor contended that the foregoing provision applied only to natural conditions that would be found in natural earth, and that the existence of old foundation walls found in the subsurface did not constitute "a difference in the character of earth to be excavated." This contention was overruled by the trial court and the complaint dismissed, and the judgment of dismissal appealed from unanimously sustained by the Appellate Division.

On a final appeal to the Court of Appeals, that court unanimously reversed both judgments of the trial court and of the Appellate Division, and granted a new trial with costs to abide the event. The *per curiam* opinion of the Court of Appeals is as follows:

> The provisions of paragraph 4 (d) of the specifications, as we read them, do not unambiguously cover the plaintiff's claim for the cost of removal of the old foundation walls. The existence of the old walls in the subjacent land was not "a difference in the character of *earth* to be excavated" and it was to "such differences in subsoil conditions" that paragraph 4 (d) was addressed. Nor is it clear enough to us that the old walls were "obstacles to the securing of a good, solid foundation" in the sense of paragraph 45 (a) of the specifications.
>
> Moreover, Article XXX of the contract provides that the reasonable value of extra work required by changes in the plans and specifications is to be added to the contract price. This provision of the contract was made inapplicable to excavation work when it was held below that the removal of the old walls was covered by the specifications above referred to. We cannot adopt that view. If there is any conflict between the provisions of the contract and those of the specifications, the former should be applied. (Dean v. Mayor, 157 N.Y. 13, 17.) We pass upon no other question.

This decision illustrates the judicial tendency to avoid any injustice that might result from a too literal or harsh application of clauses that apparently permit an owner to escape all risks and saddle them on the contractor. On the one hand, the courts have recognized that the owner should not be permitted to pass on to the contractor the cost of meeting unforeseen underground conditions that are not revealed by borings or adequate and customary preliminary investigation and that would have materially affected the contractor's bid, had they been known to exist when he made his bid. On the other hand, the courts have recognized that contracting parties have the right to cast the burden of unknown risks in underground conditions on the contractor. The reconciliation between the two conflicting principles is not always easy. Stated generally, the basis of reconciliation has been the insistence of the courts on the exercise of good faith, and freedom from deception or misrepresentation on the part of the owner and the application of the exculpatory clause only to situations that are clearly contemplated by its language.

The point of the holding in the McGarry case is that the exculpatory clause, in section 4 (d) above-quoted, did not contemplate underground conditions such as were found to exist, and that, therefore, the exculpatory clause could not be invoked to work the actual injustice on the contractor which otherwise would have been the case.

Book Notes and Reviews

The month's addition to the engineer's reading and reference list

Building Cofferdams

COFFERDAMS—By Lazarus White and E. A. Prentis. Published by Columbia University Press, New York City. Price $7.50.

Rational design of cofferdams has advanced far during the last ten years. Research in soil mechanics, in flow of water in soils, in erosion in stream beds and in lateral pressures of retained earth has since 1930 provided fundamental design data not previously possessed. With the accumulation of these data there has been a great increase in cofferdam construction for bridges, dams and navigation works. On the upper Mississippi improvements alone, lock and dam construction since 1933 has called for the building of some 150 cofferdams on erodable and permeable streambeds. Model tests sponsored by army engineers and individual contractors have been numerous for these important and hazardous structures. The accumulated knowledge from tests put to actual trial in construction has lifted cofferdam design well above old levels of empiricism. It is this new order in cofferdam development that the authors of this book discuss from actual experience as designers and contractors.

General principles are considered in three preliminary chapters on (1) hydrodynamics considering primarily flow of water in soils as related to cofferdam seepage hazards and drainage methods; (2) erosion in streams considering primarily scour and its reduction by streamlining cofferdams to reduce turbulence and eddies due to obstruction by cofferdam structures of the natural lines of flow, and (3) lateral earth pressures considering primarily the elastic theory of earth pressure. Many testing methods and test results are given in these three chapters. A brief chapter on land cofferdams follows and then the authors turn to their main subject of cofferdams in streams having erodable and permeable beds. A chapter on practical considerations (borings, types, stage construction, flood protection, erosion, closure and pumping) is followed by full accounts of the design, construction and behavior of half a score of cofferdams selected as samples of recent practice and of representative controlling conditions. The book closes with appendices on wages and prices, a glossary and a bibliography. Some 176 illustrations supplement the text. The publishers have given the book an unusually handsome dress in binding and typography.—*Reviewed by* C. S. HILL, *associate editor, retired, Engineering News-Record.*

How Sediment Fills Valleys

SOME PRINCIPLES OF ACCELERATED STREAM AND VALLEY SEDIMENTATION—By S. C. Happ, Gordon Rittenhouse and G. C. Dobson. Technical Bulletin No. 695, U. S. Dept. of Agriculture. Superintendent of Documents, Washington, D. C. Price 75c.

Detailed studies of upland erosion and sediment deposit in the valleys and streams are reported by three Soil Conservation Service men for two small drainage basins in northern Mississippi, taken as typical of areas of severe soil erosion and associated sediment damage in the Gulf Coastal Plain. Gullying of the upland and hill slopes is very marked in this region, because the soils are light and cotton and corn agriculture prevails. Soil profiles determined by boring showed that during the past 100 years or so of settlement and cultivation an average depth of 3.3 ft. of sediment was deposited on the valley bottoms. The corresponding soil volume, supplemented by (estimated) volumes of sediment carried downstream, represents 5.4 in. of soil that was eroded from the uplands of the two basins. The damage to the valley lands is estimated at 28 percent total damage and 32 percent partial damage. From the detailed observations of the nature and forms of the deposition in these valleys, coupled with general observations elsewhere, a series of principles of valley sedimentation is developed in the second part of the bulletin.

One significant finding of the authors is that the larger part of the product of erosion remains in the headwater valleys as flood plain sediment or channel filling, and that the gradient and stability of the upper courses of the stream are thereby constantly disturbed. Erosion control is believed to be the best remedy for these conditions, but suggestions are made as to ways in which the injury done to valley bottom lands can be minimized in the absence of erosion control.

New Boulder Dam Monographs

BOULDER CANYON PROJECT FINAL REPORTS—Part V—Technical Investigations: Bulletin 5, Penstock Analysis and Stiffener Design; Bulletin 6, Model Tests of Arch and Cantilever Elements. Part VII—Cement and Concrete Investigations: Bulletin I, Thermal Properties of Concrete. Published by the Bureau of Reclamation and may be obtained from the Bureau at either Denver, Colorado or Washington, D. C. Paper-bound bulletins $1 per copy; cloth-bound $1.50.

Issuance of three new volumes in the series planned to record the creative work by which the great Boulder Dam enterprise was made possible has been announced by the Bureau of Reclamation. They bring up to nine the number of volumes now in print; the full series will comprise more than thirty, covering all parts of the work from the genesis of the project to the elaborate mathematical and experimental investigations that guided the design and controlled construction.

With the volumes on "Penstock Analysis and Stiffener Design," and "Model Tests of Arch and Cantilever Elements," the group on structural design investigations nears its conclusion, leaving only research measurements at the dam to be described. The monograph on model tests outlines the strain measurements made on models of vertical and horizontal slices of the dam, constructed of a mixture of plaster and celite to a linear scale of 1:240 for the vertical section and 1:120 for the horizontal or arch section. The material of the models has a Poisson ratio and a tensile-compressive strength ratio nearly the same as those of concrete, and the work reported showed that stress distribution could be satisfactorily measured on the slab models. The results were used as a check on the conclusions from strain measure-

ments on a full (three-dimensional) model of the dam.

The detail methods of analyzing the huge steel penstock pipes are presented in the other volume. Such analysis was necessary because of the limited space available in the tunnels, and therefore the necessity of holding the stiffener rings to minimum size. The main analysis applies to the static load stresses of the pipe; following this the conical reducer sections are analyzed and water hammer effects are discussed.

First of the group of six or more volumes on cement and concrete investigations, the monograph "Thermal Properties of Concrete" sets forth the procedure by which conductivity, specific heat and diffusivity of the concrete were measured. As will be remembered, the size of Boulder Dam made the heating and cooling problem arising from generation of heat by the setting of the cement fundamentally important; calculations indicated that without preliminary cooling the dam would take 100 years to reach thermal equilibrium. For this reason, low-heat cement was used to reduce the total heat generated, and a cooling-pipe system was embedded in the blocks of the dam to carry off the heat developed during early months of the construction operations.

Geophysics in Engineering

EXPLORATION GEOPHYSICS—By J. J. Jakosky. 786 pp. Published by Times Mirror Press, Los Angeles, Cal. Price $8.

The principles of geophysics go back to the earlier days of the modern science of physics. As a working tool of the engineers its development is bounded by scarcely more than a generation of time. Its greatest practical use has been in the field of exploration for mineral-oil deposits and here it has wrought a revolution which is strikingly presented in the pages of this book. But current civil-engineering construction is witnessing an encouraging progress in the application of particularly the electrical and the seismic methods of exploration for water supplies, foundations and subsurface deposits of construction materials. Indeed seismic methods are now almost a standard in flood-protection dam building by U. S. army engineers. A book on exploration geophysics is then definitely within the field of interest of the civil engineer but more certainly that of the specialist than that of the general practitioner. This book is particularly for the specialist, it being a presentation of the fundamental theories, equipment and technique of recognized exploratory geophysical methods. In order the methods described are magnetic, gravitational, electrical, seismic, geochemical, geothermal and drill-hole investigation.

New Engineering Books

MECHANICAL WORLD YEAR BOOK 1941—266 pp. Published by Emmott & Co., Ltd., 31 King St., W., Manchester 3, England. Price 2s.

WELDING METALLURGY—By O. H. Henry and G. E. Claussen. 359 pp. Published by the American Welding Society, 33 West 39th St., New York City. Price $1.50.

BOULDER CANYON PROJECT FINAL REPORTS—Part V—Technical Investigations: Bulletin 5, Penstock Analysis and Stiffener Design; Bulletin 6, Model Tests of Arch and Cantilever Elements. Part VII—Cement and Concrete Investigations: Bulletin 1, Thermal Properties of Concrete. Published by the Bureau of Reclamation and may be obtained from the Bureau at either Denver, Colorado or Washington, D. C. Paper-bound bulletins $1 per copy; cloth-bound $1.50.

FINANCIAL STATISTICS OF CITIES 1937 (Over 100,000 population). Published by the U. S. Department of Commerce, Bureau of the Census. For sale by the Superintendent of Documents, Washington, D. C. Price $1.

THE OUTPUT OF MANUFACTURING INDUSTRIES—1899-1937—By Solomon Fabricant, with the assistance of Julius Shiskin. 685 pp.; 66 text tables; and 24 charts. Published by the National Bureau of Economic Research, Inc., New York. Price $4.50.

UNION POLICIES AND INDUSTRIAL MANAGEMENT—By Sumner H. Slichter. 597 pp. Published by The Brookings Institution, Washington, D. C. Price $3.50.

MODERN AIR CONDITIONING, HEATING AND VENTILATING—By Willis H. Carrier, Realto E. Cherne, and Walter A. Grant. 547 pp. Published by The Pitman Publishing Corp., New York and Chicago. Price $4.50.

THE NEW YORK STATE SOCIETY OF PROFESSIONAL ENGINEERS YEAR BOOK 1941—512 pp. Published by The New York State Society of Professional Engineers, Inc., Grand Central Terminal Bldg., New York. Price $10.

PRACTICAL TUNNEL DRIVING—By Harold W. Richardson and Robert S. Mayo. 436 pp. Published by McGraw-Hill Book Co., New York and London. Price $5.

APPLIED CHEMISTRY FOR ENGINEERS—By Eric S. Gyngell. 328 pp. Published by Edward Arnold & Co., London. May be obtained from Longmans Green & Co., New York. Price $4.

SIMPLIFIED DESIGN OF ROOF TRUSSES FOR ARCHITECTS AND BUILDERS—By Harry Parker. 195 pp. Published by John Wiley & Sons, Inc., New York; Chapman & Hall, London. Price $2.75.

Reports and Pamphlets

PAPERS PRESENTED AT THE TWENTY-SEVENTH ANNUAL CONFERENCE ON HIGHWAY ENGINEERING—Published by the Engineering Experiment Station, University of Illinois, Urbana, Ill. Price 50c. Circular Series No. 41.

NUMERICAL SOLUTION OF LAPLACE'S AND POISSON'S EQUATIONS with Applications to Photoelasticity and Torsion. Bulletin No. 107. Published by The Engineering Experiment Station, The Ohio State University, Columbus, Ohio. Price 60c.

COUNTY OF ESSEX (Mass.)—Annual Report of the County Engineer, 1939.

BINGHAMTON FLOOD PROTECTION PROJECT, Section No. 3, Binghamton, N. Y. U. S. Engineer Office, Binghamton, N. Y.

ECONOMIC STUDIES OF MARYLAND—Parts V and VI. Published by The Maryland State Planning Commission, Latrobe Hall, Johns Hopkins University, Baltimore, Md. Price 25c.

EXPERIENCE OF CITIES WITH PAINTED TRAFFIC LINES—Bulletin No. 4. Published by the American Public Works Association, Chicago. Price 50c.

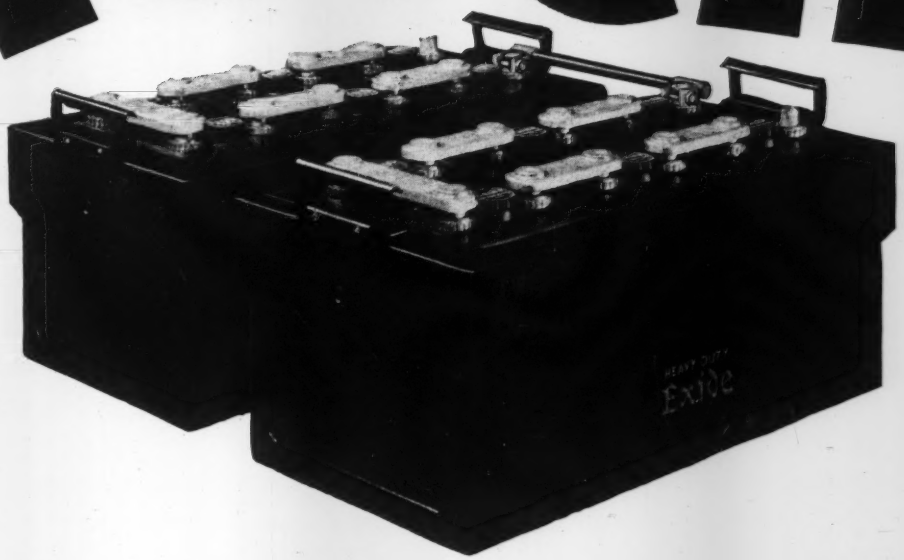
RECENT PROGRESS IN STATE LABOR LEGISLATION—Bulletin No. 42. For sale by the Supt. of Documents, Washington, D. C. Price 10c.

A YEARBOOK OF RAILROAD INFORMATION—Published by the Committee on Public Relations, 143 Liberty St., New York City.

FILTERBRUNNEN UND QUELLFASSUNGEN—By Curt F. Kollbrunner. Published by Verlag A. G. Gebr. Leemann & Co., Zurich 2, Switzerland, Stockerstrasse 64. Price Fr. 4.50.

A battery with...

PUNCH



that speeds up Diesel engine cranking

Crank a Diesel engine fast, and you get quick starting. Sounds simple . . . and it would be simple if the size and weight and cost of a battery were no object. But it takes more than ordinary battery-building skill to combine high power, high voltage, and ruggedness within a moderate-size battery of moderate cost.

High power is needed for cold engines with stiff oil. High voltage is needed for fast cranking. Ruggedness alone can give you the long, trouble-free battery life that keeps costs low. You get all three in an Exide because Exide research has developed batteries with the special qualities needed for long service in cranking Diesel engines *fast.*

There is an Exide for every size and type of Diesel engine, from the smallest to the largest. No job is too tough for an Exide. Why not write us today?

Exide
BATTERIES
FOR CRANKING
DIESEL ENGINES

THE ELECTRIC STORAGE BATTERY COMPANY, Philadelphia
The World's Largest Manufacturers of Storage Batteries for Every Purpose
Exide Batteries of Canada, Limited, Toronto

Notes on Sewage Disposal

A monthly summary of current developments conducted by Willem Rudolfs

BOMB SHELTER SANITATION — Improvising sanitary toilet facilities for the crowds of people now using the stations of the London underground railways as bomb shelters has been one of the many problems for the local authorities. It is pointed out in the *Railway Gazette* (London) that as the station platforms are below drainage level, sanitation can be provided only by means of chemical toilets, and these involve the problem of ultimate disposal of wastes. At first, the authorities undertook to handle this by manual labor, but now sewage ejectors have been installed at some of the stations. The apparatus, shown diagrammatically in the accompanying sketch, consists of a hopper into which the containers are emptied, and which drains into a 200-gal. storage cylinder or tank which is set in an inclined position. The hopper is fitted with water supply connections for washing the containers.

From the low end of the cylinder tank a 4-in. pipe is led up to a manhole on the sewer system, and the contents are blown up through this pipe by compressed air at 45 to 60-lb. pressure taken from the railway signal mains. A check valve near the tank prevents backflow. In operation, the valve isolating the hopper is shut, and compressed air then turned on. The needle of the pressure gage indicates when the tank is empty. The vertical lift ranges from 35 to 130 ft. at different stations.—*Contributed by* E. E. R. TRATMAN.

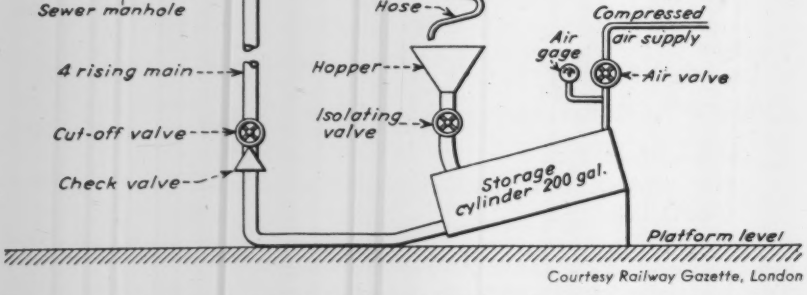
AERATION EFFICIENCY — Operation results on the same sewage with different types of aeration have now shown definitely that with equal purification results the power required is the same for simplex and direct aeration methods. Bio-aeration by the so-called Sheffield, Haworth or paddle-wheel system may be less costly in construction, but requires considerable longer detention and consequently more power than other systems as shown by results taken from the 1940 *Annual Report* of the Manchester (England) Rivers Department.

	Flow m.	Aeration hrs.	Hp. per mg.	% B.O.D. reduction
Paddle-wheels	0.642	17.2	43.5	93.1
Simplex	1.228	13.0	27.65	93.1
Diffused air	3.363	9.85	27.75	93.5

SLUDGE DRYING —Drying and handling sludge during the wet seasons becomes a problem where sludge is placed on sand beds. Various expedients have been tried including piling partly dried sludge into heaps, burying and placing on fields in sheets or rows for further drying. Piling in heaps requires considerable time for further drying and trouble is caused with weeds and grass growing on the sludge piles.

Where the sludge is sold for fertilizer uses, the problem of proper drying is of still greater importance. Various difficulties encountered at Spartanburg, S. C., led Willard, engineer for the district, to the construction of concrete floors on which to dry and condition the sludge before sale to a fertilizer company. The floors were constructed with a two-way slope, permitting the water to drain rapidly to suitable underdrains. The drying yards have an area of 35,000 sq. ft., which is equivalent to the area of the drying beds. After one year's operation involving the handling of 300 tons of sludge it was found that the average moisture content amounted to 7 percent.

Because of the additional drying facilities more frequent sludge withdrawals could be made from the tanks and digestion was more easily controlled. Mr. Willard feels that the building of these concrete drying yards has been well justified and that the construction cost will be more than compensated by the additional revenue obtained from the sludge. Sludge is sold at $1 a nitrogen unit on the dry sludge basis. Reducing the moisture content, therefore, is of added importance.



Courtesy Railway Gazette, London

Sewage ejector system used in London subway bomb shelters

BACTERIA IN STREAMS — Storage of sewage results in increased numbers of total bacteria and coliform organisms. This increase is not caused by changes of temperature. The bacterial population in a polluted stream appears to increase during the first 12 hours. Aeration and agitation of water result in higher bacterial numbers; stirring of sewage likewise causes an increase. The specific reasons for these phenomena have been under investigation for a long time.

Heukelekian and Heller (*Journal of Bacteriology*, 40, 547, Oct. 1940) conclude from experimentation that food concentration on the surface of sand, stones and debris causes the increases. When the food concentration in the liquid is very low an increase in surface area, where the food may concentrate, results in rapid bacterial increase. This explains why sand filters, trickling filters and river bottoms are effective in purification. The small quantities of food are concentrated and the bacterial population increases. Since the organisms stick to the surface where the food supply is available, stirring brings them in suspension, resulting in a higher count.

Are you building airports for today— or today and tomorrow?

Orangeburg Conduits have been installed in airports from coast to coast. More than 197,000 feet of Standard and over 330,000 feet of Nocrete are in service at La Guardia Airport.

McLaughlin Air Service

put your light and power cables in conduit and you provide for alterations and additions to field services without disrupting traffic

for main service and connections between buildings

Orangeburg Standard, encased in concrete, is the most economical construction where duct-banks of four or more ducts are involved. For nearly half a century this conduit has been serving leading utilities, railroads, municipalities, and industrials, protecting power cables underground with this type of construction.

for field lighting, contact lights, boundary lights, beacons and markers

Orangeburg Nocrete is most economical for field services as it can be installed underground without concrete encasement. Its characteristics of mechanical strength combined with exceptional deflection make it ideal for airfield service where ground stresses and settlement are encountered.

Send for this Catalog

What it is, how it is used, what it does, how it saves time, trouble, and cable . . . all the answers are contained in Catalog 46-R, a twenty-four page fully-illustrated catalog which will be sent to you without cost or obligation.

There's one right way to install power and light cables for hangars, beacons, markers, boundary and field lights. Put them underground in good conduit.

Then when cables fail, or when power loads are increased, the field extended, or new lights are added, old cable can be pulled out and new cable pulled in through the conduit—easily, economically, and without ripping up ground and disrupting field traffic.

But before you buy conduit, investigate the many advantages of Orangeburg Standard and Nocrete Conduits. Both provide *permanent* raceways—both provide *complete* cable protection. *Permanent* because being essentially hard coal-tar pitch, Orangeburg is essentially everlasting—*complete* because corrosive underground water cannot penetrate Orangeburg's walls or joints and reach the cable sheath.

And—Orangeburg offers economy—plus. Its cost is about half that of metal pipe—and because it handles easier, assembles and installs faster than *any* conduit, its total savings are well worth investigation. Write for complete information—today.

Sales Agents—Distributors

General Electric Supply Corp. Graybar Electric Co., Inc.

Build for tomorrow with

ORANGEBURG *Conduit*

MADE AT ORANGEBURG, NEW YORK BY THE FIBRE CONDUIT COMPANY, 292 MADISON AVENUE, NEW YORK CITY

Orangeburg Conduits have been approved by the Civil Aeronautics Administration and are covered by Federal Specification WC-581 approved by the Director of Procurement.

CONTRACT UNIT PRICES

What contractors are bidding on different kinds of construction work

ELEVATED PARKWAY, NEW YORK

OWNER: Triborough Bridge Authority, New York, N. Y.; Paul Loeser, gen. mgr.

PROJECT: Construction of Brooklyn Elevated Parkway on Third Ave., from 36th St. to 62nd St. (Contract B-13-15). Work involves dismantling of existing structural steel; unclassified and masonry excavation; welding; riveting; painting; erection of barricades; maintenance and protection of traffic; removing and relaying portion water mains; reinforcing of deck; and all other work necessary to complete structure. Alternates of deck bar reinforcement, or deck truss reinforcement were allowed. Contract was awarded on former.

CONDITIONS: Contractor to furnish all materials except those removed for re-use, and complete work by Aug. 18, 1941. Wage rates specified are: skilled labor, $1.25 to $2.25 per hr.; semi-skilled, $1.00 to $1.62½; and common, 87½c. per hr.; welders and acetylene torch operators to be paid at rate of mechanic in trade performing work.

BIDS: Bids were asked November 27, 1940, on Contract B-13, construction from 36th to 39th Sts.; and on Contract B-15, from 39th to 62nd. Sts.; or on the combination of the two. Contract was awarded on the combination bid of $1,648,562. Five bids were received, ranging from the contract low to $2,419,651.

LIST OF BIDDERS:

1. P. T. Cox Constr. Co., Inc., New York, N. Y. — $1,648,562
2. Harris Struct. Steel Co., New York, N. Y. — 1,678,145
3. Corbetta Constr. Co., Inc., New York, N. Y. — 1,742,671
4. Poirier & McLane Corp., New York, N. Y. — 1,819,129
5. B. Turecamo Contracting Co., Brooklyn, N. Y. — 2,419,651

Item	Quan.	Unit Prices (1)	(2)	(3)
1. Unclassified excavation	2,100 c. y.	$7 00	$15 00	$6 00
2. Masonry excavation	780 c. y.	8 00	16 00	10 00
3. Drainage leaders	6,320 l. f.	3 00	4 70	4 00
4. Portland cement	13,500 bbl.	2 20	2 05	2 25
5. Natural cement	1,740 bbl.	2 50	2 12	3 00
6. Special Portland Cement	50 bbl.	3 00	2 65	3 00
7. White cement	650 bbl.	7 50	6 30	6 00
8. Concrete for structures	7,720 c. y.	14 00	15 75	18 00
9. First class concrete	1,390 c. y.	10 00	8 50	15 00
10. Steel reinforcing bars	1,271,000 lb.	.055	.052	.05
11. Structural steel	9,780,000 lb.	.086	.083	.08
12. Existing steel cut	16,600 s. i.	.55	.35	.55
13. Rivets (removed)	54,000 ea.	.40	.60	.44
14. Rivets (heads removed)	34,500 ea.	.30	.25	.33
15. Holes	2,400 ea.	1 10	.90	1 65
16. Single layer weld	85,000 l. f.	1 10	1 05	1 32
17. Multi-layer weld	7,700 l. f.	1 50	1 40	1 93
18. New rivets	14,200 ea.	1 50	.60	.50
19. New metal parts	890,000 lb.	.11	.075	.084
20. Holes plugged and welded	2,200 ea.	.55	.45	.55
21. Dismantle exist. struct. steel	L.S.	15,000 00	10,000 00	95,000 00
22. Re-erect struct. steel	1,000 ton	7 00	36 00	20 00
23. Lead plate	7,700 lb.	.12	.12	.16
24. Drainage scuppers	45,700 lb.	.09	.077	.14
25. Lamp post sockets, type A	5 ea.	40 00	90 00	60 00
26. Lamp post sockets, type B	1 ea.	40 00	90 00	60 00
27. Lamp post sockets, type C	40 ea.	32 00	80 00	60 00
28. Field painting	L.S.	24,000 00	55,000 00	60,000 00
29. Maintain and protect traffic	L.S.	5,000 00	9,900 00	10,000 00
30. Barricades	200 l. f.	5 00	2 10	3 00
31. 16-in. clos. end steel pipe piles	8,200 l. f.	4 50	4 15	4 25
32. 18-in. clos. end steel pipe piles	3,000 l. f.	5 50	5 10	5 25
33. Load tests on 16-in. piles	6 ea.	300 00	400 00	500 00
34. Load tests on 18-in. piles	2 ea.	400 00	500 00	650 00
35. Soil loading tests	50 ea.	200 00	200 00	140 00
36. Shore columns and ends of fl. beams	100 ea.	50 00	50 00	140 00
37. Demolition	L.S.	56,000 00	71,000 00	35,000 00
38. Electrical conduits	67,000 lb.	.15	.17	.19
39. Electrical boxes	9,900 lb.	.40	.40	.40
40. 20-in. high press. c.i. water pipe laid	60 l. f.	15 00	8 00	3 50
41. 20-in. c.i. water pipe laid	60 l. f.	15 00	6 00	3 25
42. 20-in. hi. press. wat. main removed	40 l. f.	12 50	4 00	3 00
43. 20-in. water main removed	40 l. f.	12 50	2 00	3 00
44. *Deck bar reinforcement	1,300,000 lb.	.05	.052	.053
45. *Deck truss reinforcement	1,740,000 lb.	.05	.....	.....

*Alternates.

HIGHWAYS, KENTUCKY

OWNER: Department of Highways, Frankfort, Ky.

PROJECT: Realignment and reconstruction of portion of U. S. Highway 60 between Shelbyville and Frankfort, Ky. Present roadway is 18-ft. wide; new roadway will be graded 38-ft. on fills, and 50-ft. in cuts. Length of improvement project, 6.475 miles. Includes construction of 2-span bridge, and one 5-span reinforced concrete deck girder bridge. Both older bridges to be removed, and detour bridge constructed to take care of traffic during construction period.

CONDITIONS: Project is part of what was to have been the biggest job in the state, but is now one of four similar projects which were broken down to expedite construction as work is on a strategic military network. Contractor to furnish all materials and complete work by Sept. 3, 1941. Rail and highway transportation facilities available. Wage rates stipulated are: skilled, 90c. to $1.25 per hr.; semi-skilled, 60 to 75c.; common, 40c.

BIDS: Seven bids were received December 13, 1940, ranging from the contract low of $185,151 to $233,739.

LIST OF BIDDERS:

1. Codell Constr. Co., Winchester, Ky. (contract) — $185,151
2. Harry Hatfield & Co., Barboursville, W. Va. — 188,665
3. John F. Bloomer, Appleton, Wis. — 189,651
4. Ralph E. Mills Co. & S. J. Boone, Frankfort and Owensboro, Ky. — 215,184
5. F. C. Gorrell & Sons, Russellville, Ky. — 218,757
6. Ralph Rogers & Co., Louisville, Ky. — 227,994
7. Mautz & Oren, Inc., Effingham, Ill. — 233,739

Item	Quan.	Unit Prices (1)	(2)	(3)
1. Clear and grub	87.27 ac.	$10 00	$15 00	$15 00
2. Roadway excavation	279,315 c. y.	.25	.25	.28
3. Struct. excav., unclassified	1,288 c. y.	1 10	1 50	1 00
4. Struct. excav., common	3,050 c. y.	.90	1 00	1 00
5. Struct. excav., solid rock	1,080 c. y.	2 50	3 00	3 00
6. Final dressing	342 sta.	8 00	10 00	7 00
7. Overhaul	57,380 y. sta.	.01	.01	.005
8. Scarify and reshape	15,000 s. y.	.01	.03	.05
9. Remove exist. metal	530 s. y.	.05	.10	.10
10. Remove dry stone masonry	302 c. y.	.60	1 00	1 00
11. Remove wet stone masonry	163 c. y.	1 00	1 50	1 00
12. Remove concrete masonry	592 c. y.	2 50	3 00	2 00
13. Remove pipe	2,440 l. f.	.35	.50	.40
14. Relay pipe	513 l. f.	.40	.50	.50
15. Remove concrete walk	2,110 s. y.	.15	.20	.20
16. Remove dry stone fence	966 c. y.	.60	1 00	.50
17. Rebuild dry stone fence	953 c. y.	3 50	2 50	2 50
18. Rebuild wet stone masonry	94 c. y.	9 50	7 00	8 00
19. Remove concrete pavement	224 s. y.	.50	.75	.50
20. Remove brick walk	28 s. y.	.25	.50	.20
21. Relay brick walk	14 s. y.	1 00	1 00	1 00
22. 15-in. bit. coat. corr. met. pipe	42 l. f.	1 55	1 35	2 00
23. Remove, reset hedge fence	1,172 l. f.	.40	.40	.20
24. 4-in. concrete sidewalk	20 s. y.	2 00	2 00	2 00
25. Remove, rebuild dry stone mas. wall	45 c. y.	4 10	3 50	6 00
26. Class B concrete	195.5 c. y.	17 00	18 00	18 00
27. Remove guard rail	800 l. f.	.10	.20	.20
28. Remove, reset mile stone posts	2 ea.	2 50	3 00	10 00
29. Rural pipe inlets	2 ea.	75 00	50 00	100 00
30. Crushed limestone (loose)	1,500 ton	1 70	1 50	1 60
31. Surf. ditches (1-s. f. area)	3,500 l.f.	.08	.05	.08
32. Surf. ditches (2-s. f. area)	2,200 l. f.	.16	.20	.10
33. 6-in. sewer pipe	140 l. f.	.35	.40	.80
34. Water	25,485 hund. gal.	.10	.125	.10
35. Class A concrete	2,834.58 c. y.	18 00	18 50	18 50
36. Class D concrete	37.4 c. y.	50 00	50 00	50 00
37. Reinforcing steel	387,900 lb.	.0375	.0425	.045
38. Remove existing structures	2 ea.	950 00	500 00	500 00
39. Bronze expansion plates	1,064 lb.	.55	.50	.50
40. Detour bridge	L.S.	4,700 00	4,000 00	4,000 00
41. 15-in. corr. met. entrance pipe	1,213 l. f.	1 35	1 15	1 10
42. 18-in. corr. met entrance pipe	347 l. f.	1 55	1 65	1 50
43. 24-in. corr. met. entrance pipe	170 l. f.	2 50	2 50	2 20
44. 18-in. rein. conc. culv. pipe	522 l. f.	1 80	1 65	1 80
45. 24-in. rein. conc. culv. pipe	372 l. f.	2 70	2 50	2 50
46. 30-in. rein. conc. culv. pipe	267 l. f.	3 75	3 50	3 50
47. 36-in. rein. conc. culv. pipe	288 l. f.	5 00	6 00	5 00
48. 42-in. rein. conc. culv. pipe	117 l. f	6 25	7 00	6 00
49. 24-in. rein. conc. ex. str. culv. pipe	81 l. f.	3 25	3 00	3 00
50. 15-in. rein. conc. sewer pipe	884 l. f.	2 05	1 90	1 70
51. 18-in. rein. conc. sewer pipe	591 l. f.	2 45	1 25	2 20

]

]

ven

CONTRACT UNIT PRICES

What contractors are bidding on different kinds of construction work

ELEVATED PARKWAY, NEW YORK

OWNER: Triborough Bridge Authority, New York, N. Y.; Paul Loeser, gen. mgr.

PROJECT: Construction of Brooklyn Elevated Parkway on Third Ave., from 36th St. to 62nd St. (Contract B-13-15). Work involves dismantling of existing structural steel; unclassified and masonry excavation; welding; riveting; painting; erection of barricades; maintenance and protection of traffic; removing and relaying portion water mains; reinforcing of deck; and all other work necessary to complete structure. Alternates of deck bar reinforcement, or deck truss reinforcement were allowed. Contract was awarded on former.

CONDITIONS: Contractor to furnish all materials except those removed for re-use, and complete work by Aug. 18, 1941. Wage rates specified are: skilled labor, $1.25 to $2.25 per hr.; semi-skilled, $1.00 to $1.62½; and common, 87½c. per hr.; welders and acetylene torch operators to be paid at rate of mechanic in trade performing work.

BIDS: Bids were asked November 27, 1940, on Contract B-13, construction from 36th to 39th Sts.; and on Contract B-15, from 39th to 62nd. Sts.; or on the combination of the two. Contract was awarded on the combination bid of $1,648,562. Five bids were received, ranging from the contract low to $2,419,651.

LIST OF BIDDERS:

1. P. T. Cox Constr. Co., Inc., New York, N. Y. $1,648,562
2. Harris Struct. Steel Co., New York, N. Y. 1,678,145
3. Corbetta Constr. Co., Inc., New York, N. Y. 1,742,671
4. Poirier & McLane Corp., New York, N. Y. 1,819,129
5. B. Turecamo Contracting Co., Brooklyn, N. Y. 2,419,651

Item	Quan.	Unit Prices (1)	(2)	(3)
1. Unclassified excavation	2,100 c. y.	$7 00	$15 00	$6 00
2. Masonry excavation	780 c. y.	8 00	16 00	10 00
3. Drainage leaders	6,320 l. f.	3 00	4 70	4 00
4. Portland cement	13,500 bbl.	2 20	2 05	2 25
5. Natural cement	1,740 bbl.	2 50	2 12	3 00
6. Special Portland Cement	50 bbl.	3 00	2 65	3 00
7. White cement	650 bbl.	7 50	6 30	6 00
8. Concrete for structures	7,720 c. y.	14 00	15 75	18 00
9. First class concrete	1,390 c. y.	10 00	8 50	15 00
10. Steel reinforcing bars	1,271,000 lb.	.055	.052	.05
11. Structural steel	9,780,000 lb.	.086	.083	.08
12. Existing steel cut	16,600 s. i.	.55	.35	.55
13. Rivets (removed)	54,000 ea.	.40	.60	.44
14. Rivets (heads removed)	34,500 ea.	.30	.25	.33
15. Holes	2,400 ea.	1 10	.90	1 65
16. Single layer weld	85,000 l. f.	1.10	1 05	1 32
17. Multi-layer weld	7,700 l. f.	1 50	1 40	1 93
18. New rivets	14,200 ea.	1.50	.60	.50
19. New metal parts	890,000 lb.	.11	.075	.084
20. Holes plugged and welded	2,200 ea.	.55	.45	.55
21. Dismantle exist. struct. steel	L.S.	15,000 00	10,000 00	95,000 00
22. Re-erect struct. steel	1,000 ton	7 00	36 00	20 00
23. Lead plate	7,700 lb.	.12	.12	.16
24. Drainage scuppers	45,700 lb.	.09	.077	.14
25. Lamp post sockets, type A	5 ea.	40 00	90 00	60 00
26. Lamp post sockets, type B	1 ea.	40 00	90 00	60 00
27. Lamp post sockets, type C	40 ea.	32 00	80 00	60 00
28. Field painting	L.S.	24,000 00	55,000 00	60,000 00
29. Maintain and protect traffic	L.S.	5,000 00	9,900 00	10,000 00
30. Barricades	200 l. f.	5 00	2 10	3 00
31. 16-in. clos. end steel pipe piles	8,200 l. f.	4 50	4 15	4 25
32. 18-in. clos. end steel pipe piles	3,000 l. f.	5 50	5 10	5 25
33. Load tests on 16-in. piles	6 ea.	300 00	400 00	500 00
34. Load tests on 18-in. piles	2 ea.	400 00	500 00	650 00
35. Soil loading tests	50 ea.	200 00	200 00	140 00
36. Shore columns and ends of fl. beams	100 ea.	50 00	50 00	140 00
37. Demolition	L.S.	56,000 00	71,000 00	35,000 00
38. Electrical conduits	67,000 lb.	15	17	19
39. Electrical boxes	9,900 lb.	40	40	40
40. 20-in. high press. c.i. water pipe laid	60 l. f.	15 00	8 00	3 50
41. 20-in. c.i. water pipe laid	60 l. f.	15 00	6 00	3 25
42. 20-in. hi. press. wat. main removed	40 l. f.	12 50	4 00	3 00
43. 20-in. water main removed	40 l. f.	12 50	2 00	3 00
44. *Deck bar reinforcement	1,300,000 lb.	.05	.052	.053
45. *Deck truss reinforcement	1,740,000 lb.	.05	.....	.....

*Alternates.

HIGHWAYS, KENTUCKY

OWNER: Department of Highways, Frankfort, Ky.

PROJECT: Realignment and reconstruction of portion of U. S. Highway 60 between Shelbyville and Frankfort, Ky. Present roadway is 18-ft. wide; new roadway will be graded 38-ft. on fills, and 50-ft. in cuts. Length of improvement project, 6.475 miles. Includes construction of 2-span bridge, and one 5-span reinforced concrete deck girder bridge. Both older bridges to be removed, and detour bridge constructed to take care of traffic during construction period.

CONDITIONS: Project is part of what was to have been the biggest job in the state, but is now one of four similar projects which were broken down to expedite construction as work is on a strategic military network. Contractor to furnish all materials and complete work by Sept. 3, 1941. Rail and highway transportation facilities available. Wage rates stipulated are: skilled, 90c. to $1.25 per hr.; semi-skilled, 60 to 75c.; common, 40c.

BIDS: Seven bids were received December 13, 1940, ranging from the contract low of $185,151 to $233,739.

LIST OF BIDDERS:

1. Codell Constr. Co., Winchester, Ky. (contract) $185,151
2. Harry Hatfield & Co., Barboursville, W. Va. 188,665
3. John F. Bloomer, Appleton, Wis. 189,651
4. Ralph E. Mills Co. & S. J. Boone, Frankfort and Owensboro, Ky. 215,184
5. F. C. Gorrell & Sons, Russellville, Ky. 218,757
6. Ralph Rogers & Co., Louisville, Ky. 227,994
7. Mautz & Oren, Inc., Effingham, Ill. 233,739

Item	Quan.	Unit Prices (1)	(2)	(3)
1. Clear and grub	87.27 ac.	$10 00	$15 00	$15 00
2. Roadway excavation	279,315 c. y.	.25	.25	.28
3. Struct. excav., unclassified	1,288 c. y.	1 10	1 50	1 00
4. Struct. excav., common	3,050 c. y.	.90	1 00	1 00
5. Struct. excav., solid rock	1,080 c. y.	2 50	3 00	3 00
6. Final dressing	342 sta.	8 00	10 00	7 00
7. Overhaul	57,380 y. sta.	.01	.01	.005
8. Scarify and reshape	15,000 s. y.	.01	.03	.05
9. Remove exist. metal	530 s. y.	.05	.10	.10
10. Remove dry stone masonry	302 c. y.	.60	1 00	1 00
11. Remove wet stone masonry	163 c. y.	1 00	1 50	1 00
12. Remove concrete masonry	592 c. y.	2 50	3 00	2 00
13. Remove pipe	2,440 l. f.	.35	.50	.40
14. Relay pipe	513 l. f.	.40	.50	.50
15. Remove concrete walk	2,110 s. y.	.15	.20	.20
16. Remove dry stone fence	966 c. y.	.60	1 00	.50
17. Rebuild dry stone fence	953 c. y.	3 50	2 50	2 50
18. Rebuild wet stone masonry	94 c. y.	9 50	7 00	8 00
19. Remove concrete pavement	224 s. y.	.50	.75	.50
20. Remove brick walk	28 s. y.	.25	.50	.20
21. Relay brick walk	14 s. y.	1 00	1 00	1 00
22. 15-in. bit. coat. corr. met. pipe	42 l. f.	1 55	1 35	2 00
23. Remove, reset hedge fence	1,172 l. f.	.40	.40	.20
24. 4-in. concrete sidewalk	20 s. y.	2 00	2 00	2 00
25. Remove, rebuild dry stone mas. wall	45 c. y.	4 10	3 50	6 00
26. Class B concrete	195.5 c. y.	17 00	18 00	18 00
27. Remove guard rail	800 l. f.	.10	.20	.20
28. Remove, reset mile stone posts	2 ea.	2 50	3 00	10 00
29. Rural pipe inlets	2 ea.	75 00	50 00	100 00
30. Crushed limestone (loose)	1,500 ton	1 70	1 50	1 60
31. Surf. ditches (1-s. f. area)	3,500 l.f.	.08	.05	.08
32. Surf. ditches (2-s. f. area)	2,200 l. f.	.16	.20	.10
33. 6-in. sewer pipe	140 l. f.	.35	.40	.80
34. Water	25,485 hund. gal.	.10	.125	.10
35. Class A concrete	2,834.58 c. y.	18 00	18 50	18 50
36. Class D concrete	37.4 c. y.	50 00	50 00	50 00
37. Reinforcing steel	387,900 lb.	.0375	.0425	.045
38. Remove existing structures	2 ea.	950 00	500 00	500 00
39. Bronze expansion plates	1,064 lb.	.55	.50	.50
40. Detour bridge	L.S.	4,700 00	4,000 00	4,000 00
41. 15-in. corr. met. entrance pipe	1,213 l. f.	1 35	1 15	1 10
42. 18-in. corr. met entrance pipe	347 l. f.	1 55	1 65	1 50
43. 24-in. corr. met. entrance pipe	170 l. f.	2 50	2 50	2 20
44. 18-in. rein. conc. culv. pipe	522 l. f.	1 80	1 65	1 80
45. 24-in. rein. conc. culv. pipe	372 l. f.	2 70	2 50	2 50
46. 30-in. rein. conc. culv. pipe	267 l. f.	3 75	3 50	3 50
47. 36-in. rein. conc. culv. pipe	288 l. f.	5 00	6 00	5 00
48. 42-in. rein. conc. culv. pipe	117 l. f	6 25	7 00	6 00
49. 24-in. rein. conc. ex. str. culv. pipe	81 l. f.	3 25	3 00	3 00
50. 15-in. rein. conc. sewer pipe	884 l. f.	2 05	1 90	1 70
51. 18-in. rein. conc. sewer pipe	591 l. f.	2 45	1 25	2 20

ver